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THE ORIGIN OF LUNGS, A CHAPTER IN EVOLUTION.

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The air bladder of fishes is an organ whose true purpose has long been classed among the mysteries of animal organization. All we know about it is the duty to which it is now occasionally devoted; but there is abundant reason to believe that this was not its original function. This duty is indicated by its frequent title of "swim-bladder," the organ being seemingly used to some extent to aid the fish in swimming. Cuvier tells us that "the most obvious use of the swim-bladder is to keep the animal in equilibrium with the water, or to increase or reduce its relative weight, and thereby cause it to ascend or sink, in proportion as that organ is dilated or compressed." In addition it may be of use, as Günther observes, "in raising the fore-part of the body or depressing it, as occasion may require."

Doubtless all this is correct, but that the bladder was evolved for such a purpose, or is of any essential utility as a swimming organ, there is the strongest reason to question; and in all probability its original purpose was something quite different. As it at present exists it is often too small to be of use in changing the gravity of the fish, and in many cases it is entirely absent. In others, its compressing muscles, as Van der Hœven states, seem incapable of being used to expand it. Yet in all these cases the fish seems at no disadvantage in swimming as compared with those that possess large and

efficient bladders. As an instance may be cited the mackerel, which has no bladder, yet which certainly finds no difficulty in rising or sinking. The same may be said of the great shark tribe, which is bladderless. All this goes to indicate that the air bladder could not have been developed originally for such a purpose, since its use as a swim-bladder seems of such little value to the fish that it has been frequently suffered to degenerate and disappear, and even if such a service were essential to the fish tribe it is impossible to conceive that this organ could have been of utility in swimming in the earlier stages of its development.

Before considering, however, the question of the original purpose of the air-bladder, some description of its present conditions is necessary. This organ is an internal sac, possessed by many, but not by all, fishes, and is situated ordinarily in the dorsal region of the body, between the vertebræ and the intestines, and in front of the kidneys. It lies outside the peritoneal sac, a fold of which invests its ventral surface. Its relation to the surrounding organs varies. In many cases it is intimately adherent to the vertebral column and the abdominal tissues, and is often enclosed in osseous capsules formed by the vertebræ. In such cases it may readily be compressed or expanded, and the weight of the fish in relation to the water be thus changed. But in other instances it is almost loose in the abdominal cavity, and seemingly incapable of acting as a gravity organ.

It varies greatly both in size and form. In some fishes it is so large as to extend into the tail, while in other instances it sends processes into the head; these having some connection with the organ of hearing. In many fishes, on the contrary, it is small, sometimes so minute as to be of no conceivable utility. In numerous instances it is entirely absent. And here we find the highly significant fact that variations of this kind occur in closely related species. Thus, as has been already said, the mackerel has no air-bladder. Yet one exists in *Scomber pneumatophorus*, a species which in every other respect closely resembles the mackerel. Similarly in the genus *Polynemus* one species (*paradiseus*) is destitute of an air-

bladder, while every other species possesses one. A like singular variation occurs in the case of related genera. In the genus *Sebastes* the air-bladder is very large, yet in a closely related genus it is scarcely the size of a pea.

Its variations in form are equally marked. Ordinarily it is a simple sac, with smooth interior. Yet in some instances it has a cellular interior, and in others it is divided by transverse partitions into from two to four sections. In other cases it is divided by a longitudinal partition into two lateral halves. In some families there is a remarkable development of lateral appendages, of varying character. In others the internal sacculation becomes so great that the bladder resembles the batrachian lung, and evidently does duty in the breathing of air.

The bladder itself is composed of two layers of membrane, the outer one being usually provided with muscular fibres, while the inner one is abundantly supplied with blood vessels. These take the form of capillary plexuses, or what are known as *retia mirabilia*, whose purpose may be to secrete the gas with which the bladder is filled. This gas differs in character in different fishes. In fresh-water fishes it is nearly pure nitrogen, the percentage of oxygen being small. In marine fishes, on the contrary, oxygen is in excess. This is particularly the case in the deep-swimmers, in some of which the bladder has been found to contain as much as eighty-seven per cent. of oxygen.

These gaseous contents, if, as seems probable, obtained through secretion by the blood vessels, are not always so obtained, for in many fishes an arrangement exists by which air may directly enter the bladder from without. This is what is known as the pneumatic duct, a tubular connection between the œsophagus and the air-bladder, not unlike that which supplies the lungs of air-breathers. This duct presents the same remarkable variability which we have observed in other characteristics of the air-bladder. Its point of connection with the alimentary tract varies, being usually in the œsophagus, but in some fishes as far back as the stomach. In the Ganoid order of fishes the duct is a short one, and always

open. In the Physostome order it is longer, and in many instances is closed, it being occasionally reduced to a fine filament. In the other orders of Teleostean fishes, which embrace the great majority of species, the pneumatic duct does not exist. Whatever function this duct may have once performed, therefore, it seems as a rule to have lost its utility. That its function was an essential one in the early stage of fish life is rendered evident by the fact that all fishes which have a bladder at all possess a pneumatic duct in the larval stage of growth, this duct, in most cases, vanishing as they grow older.

If now we seek to discover the original purpose of this organ, there is abundant reason to believe that it had nothing to do with swimming. Certainly the great family of the sharks, which have no bladder, are at no disadvantage in changing their depth or position in the water. Yet if the bladder is necessary to any fish as an aid in swimming, why not to all? And if this were its primary purpose, how shall we explain its remarkable variability? No animal organ with a function of essential importance presents such extraordinary modifications in related species and genera. In the heart, brain, and other organs there is one shape, position, and condition of greatest efficiency, and throughout the lower forms we find a steady advance towards this condition. Great variation, on the other hand, usually indicates that the organ is of little functional importance, or that it has lost its original function. Such we conceive to be the case with the air-bladder. The fact of its absence from some and its presence in other fishes of closely related species, goes far to prove that it is a degenerating organ; and the same is shown by the fact that it is useless in some species for the purpose to which it is applied in others. That it had, at some time in the past, a function of essential importance there can be no question. That it exists at all is proof of this. But its modern variations strongly indicate that it has lost this function, and is on the road towards extinction. Larval conditions show that it had originally a pneumatic duct as one of its essential parts, but this has in most cases disappeared. The bladder itself has in many cases partly or wholly disappeared. Where preserved, it seems to be through

its utility for some secondary purpose, such as an aid in swimming or in hearing. That its evolution began very long ago there can be no question; and the indications are that it began long ago to degenerate, through the loss of its primitive function.

What was this primitive function? In attempting to answer this question we must first consider the air-bladder in relation to the fish tribe as a whole. In one principal order of fishes, the Elasmobranchs, the air-bladder does not exist. No shark or ray possesses this organ. In some few sharks, indeed, there is a diverticulum of the pharynx which may be a rudimentary approach to the air-bladder; but this is very questionable. The conditions of its occurrence in the main body of modern fishes, the Teleostean, we have already considered. But in the most ancient existing order of fishes, the Ganoids, of which but a few representatives remain, it exists in an interesting condition. In every modern Ganoid the air-bladder has an effective pneumatic duct, which usually opens into the dorsal side of the œsophagus, but in the sub-order Polypterus opens, like the wind-pipe of lung-breathers, into the ventral side. Finally, in the small sub-order of Dipnoi, also a survivor from the remote past, the duct not only opens ventrally into the œsophagus, but the air-bladder does duty as a lung. Externally it differs in no particular from an air-bladder; but internally it presents a cellular structure which nearly approaches that of the lung of the bactrachians. There are three existing representatives of the Dipnoi. One of these, the Australian lung-fish (*Ceratodus*), has a single bladder, which, however, is provided with breathing pouches having a symmetrical lateral arrangement. It has no pulmonary artery, but receives branches from the *Arteria cœliaca*. In the other two forms, *Lepidosiren* and *Protopterus*,—the kindred "mud fishes" of the Amazon basin and tropical Africa,—the bladder or lung is divided into two lateral chambers as in land animals, and is provided with a separate pulmonary artery.

The opinion seems to be tacitly entertained by physiologists that this employment of the air-bladder by the Dipnoi as a

lung is a secondary adaptation, a side issue from its original purpose. To this I venture to oppose the theory (which I have already offered in the "Proceedings" of the Academy of Natural Sciences of Philadelphia) that it is the original purpose, and that its degeneration is due to the disappearance of the necessity of such a function. As regards the gravitative employment of the bladder, the Teleostean fishes, to which this function is confined, are of comparatively modern origin; while the Dipnoi are surviving representatives of a very ancient order of fishes, which flourished in the Devonian age of geology, and in all probability breathed air then as now; and the Ganoids, which approach them in this particular, are similarly ancient in origin, and were the ancestors of the Teleosteans. The natural presumption, therefore, is that the duty which it subserved in the most ancient fishes was its primitive function.

The facts of embryology lend strong support to this hypothesis. For the air-bladder is found to arise in a manner very similar to the development of the lung. They each begin as an outgrowth from the fore-part of the alimentary tract, the only difference being that the air-bladder usually rises dorsally and the lung ventrally. The fact already cited, that the pneumatic duct is always present in the larval form, in fishes that possess a bladder, is equally significant. All the facts go to show that the introduction of external air into the body was a former function of the air-bladder, and that the atrophy of the duct in many cases, and the disappearance of the bladder in others, are results of the loss of this function.

Such an elaborate arrangement for the introduction of air into the body could have, if we may judge from analogy, but one purpose, that of breathing, to which purpose the muscular and other apparatus for compressing and dilating the bladder, now seemingly adapted to gravitative uses, may have been originally applied. The same may be said of the great development of blood capillaries in the inner tunic of the bladder. These may now be used only for the secretion of gas into its interior, but were perhaps originally employed in the respiratory secretion of oxygen. In fact, all the circum-

stances mentioned—the similarity in larval development between bladder and lung, the larval existence of the pneumatic duct, the arrangements for compressing and dilating the bladder, and the capillary vessels on its inner tunic—point to the breathing of air as its original purpose.

It is probable that the Ganoid, as well as the Dipnoid, bladder, is to some extent still used in breathing. The Dipnoi have both lungs and gills, and probably breathe with the latter in ordinary cases, but use their lungs when the inland waters in which they live become thick and muddy, or are charged with gases from decomposing organic matter. The Ganoid fishes to some extent breathe the air. In *Polypterus* the air-bladder resembles the Dipnoid lung in having lateral divisions, and a ventral connection with the œsophagus, while in *Lepidosteus* (the American Gar Pike) it is cellular and lung-like. This fish keeps near the surface, and may be seen to emit air-bubbles, probably taking in a fresh supply of air. The American Bow-Fin or Mud Fish (*Amia*) has a bladder of the same lung-like character, and has been seen by Wilder to come to the surface, open its jaws widely, and apparently swallow a large quantity of air. He considers that both *Lepidosteus* and *Amia* inhale and exhale air at somewhat regular intervals, resembling in this the salamanders and tadpoles, "which, as the gills shrink and the lungs increase, come more frequently to the surface for air."

As the facts stand there is no evident line of demarcation between the gas-containing bladders of many of the Teleosteans, the air-containing bladders of others and of the Ganoids, and the lung of the Dipnoi, and the indications are in favor of their having originally had the same function, and of this being the breathing of air.

If now we ask, what were the conditions of life under which this organ was developed, and what the later conditions which rendered it of no utility as a lung, some definite answer may be given. The question takes us back to the Devonian and Silurian geological periods, during which the original development of the bladder probably took place. In this era the seas were thronged with fishes of two distinct orders, the Elasmo-

branchs and the Dipnoi, with the Ganoids as a branch of the true fishes. The former were without, the latter with, an air-bladder; a difference in organization which was most likely due to some marked difference in their life habits. The Elasmobranchs were the monarchs of the seas, against whose incursions the Ganoids put on a thick protective armor, and probably sought the shallow shore waters, while their foes held chief possession of the deeper waters without.

We seem, then, to perceive the Ganoid fishes driven by their foes into bays and estuaries and the waters of shallow coasts, ascending streams, and dwelling in inland waters. Here two influences probably acted on them. The waters they dwelt in were often thick with sediment, and were doubtless in many instances poorly aerated, rendering gill-breathing difficult. And the land presented conditions likely to serve as a strong inducement to fishes to venture on shore. Its plant life was abundant, while its only animal inhabitants seem to have been insects, worms, and snails. There can be little doubt that the active fish forms of that period, having no enemies to fear on the land, and much to gain, made active efforts to obtain a share of this vegetable and animal food. Even to-day, when they have numerous foes to fear, many fishes seek food on the shore, and some even climb trees for this purpose. Under the conditions of the period mentioned there was a powerful inducement for them to assume this habit.

Such conditions must have strongly tended to induce fishes to breathe the air, and have acted to develop an organ for this purpose. In addition to the influences of foul or muddy water and of visits to land, may be named that of the drying-out of pools, by which fishes are sometimes left in the moist mud till the recurrence of rains, or are even buried in the dried mud during the rainless season. This is the case with the modern Dipnoi, which use their lungs under such circumstances. In certain other fresh-water fishes, of the family Ophiocephalidæ, air is breathed while the mud continues soft enough for the fish to come to the surface, but during the dry period the animal remains in a torpid state. These fishes have no lungs, but breathe the air into a simple cavity in the pharynx, whose

opening is partly closed by a fold of the mucous membrane. Another family, the Labyrinthici, of similar habits, possesses a more developed breathing organ. This is a cavity formed by the walls of the pharynx, in which are thin laminæ or plates, which undoubtedly perform an oxygenating function. The most interesting member of this family is *Anabas scandens*, the Climbing Perch. In this fish, which not only leaves the water, but climbs trees, the air-breathing organ is greatly developed. The Labyrinthici moreover have usually large air-bladders. As regards the occasional breathing of air by fishes, even in species which do not leave the water, it is quite common, particularly among fresh-water species. Cuvier remarks that air is perhaps necessary to every kind of fish; and that, particularly when the atmosphere is warm, most of our lacustrine species sport on the surface for no other purpose.

It is not difficult to draw a hypothetical plan of the development of the air-bladder as a breathing organ. In the two families of fishes just mentioned, whose air-bladders indicate that they once possessed the air-breathing function and have lost it, we perceive the process of formation of an air-breathing organ beginning over again, under stress of similar circumstances. The larval development of the air-bladder points significantly in the same direction. In fact, we have strong reason to believe that air-breathing in fishes was originally performed, as it probably often is now, by the unchanged walls of the œsophagus. Then these walls expanded inwardly, forming a simple cavity, partly closed by a fold of membrane, like that of the Ophiocephalidæ. A step further reduced this membraneous fold to a narrow opening, leading to an inner pouch. As the air-breathing function developed, the opening became a tube, and the pouch a simple lung, with compressing muscles and capillary vessels. By a continuation of the process the smooth-walled pouch became sacculated, its surface being increased by folding into breathing cells. Finally a longitudinal constriction divided it into two lateral pouches, such as we find in the lung of the Dipnoi. This brings us to the verge of the lung of the Batrachia, which is but a step in

advance, and from that the line of progress is unbroken to the more intricate lung of the higher land animals.

The dorsal position of the bladder and its duct would be a difficulty in this inquiry, but for the fact that the duct is occasionally ventral. This dorsal position may have arisen from the upward pressure of air in the swimming fish, which would tend to lift the original pouch. But in the case of fishes which made frequent visits to the shore, new influences must have come into play. The effect of gravity tended to draw the organ and its duct downward, as we find in one family of the Ganoids and in all the Dipnoi; and its increased use in breathing required a more extended surface. Through this requirement came the pouched and cellular lung of the Dipnoi. Of every stage of the process here outlined, examples exist, and there is great reason to believe that the development of the lung followed the path above pointed out.

When the carboniferous era opened there may have been many lung- and gill-breathing Dipnoi, which spent much of their time on land, and some of which, by a gradual improvement in their organs of locomotion, changed into batrachians. But with the appearance of the latter, and of their successors, the reptiles, the relations of the fish to the land radically changed. The fin, or the simple locomotor organ of the Dipnoi, could not compete with the leg and foot as organs of land locomotion, and the fish tribe ceased to be lords of the land, where instead of feeble prey they now found powerful foes, and were driven back to their native habitat, the water. Nor did the change end here. In time the waters were invaded by the reptiles, numerous swimming forms appearing, which it is likely were abundant in the shallower shore line of the ocean, while they sent many representatives far out to sea. These were actively carnivorous, making the fish their prey, the great mass of whom were doubtless driven into the deeper waters, beyond the reach of their air-breathing foes.

In this change of conditions we seem to perceive an adequate cause for the loss of air-breathing habits in those fishes in which the lung development had not far progressed. It may, indeed, have been a leading influence in the development of

the Teleostean or bony fishes, as it doubtless was in the loss of its primitive function by, and the subsequent changes of, the air-bladder.

Such of the Ganoids and Dipnoi as survived in their old condition had to contend with adverse circumstances. Most of them in time vanished, while the Ganoids which still exist have lost in great measure their air-breathing powers, and the Dipnoi, in which the development of the lung had gone too far for reversal, have degenerated into eel-like, mud-haunting creatures, in which the organs of locomotion, which perhaps once served them efficiently for land travel, have become converted into the feeble paddle-like limb of Ceratodus and the filamentary appendages of the other species.

As regards the presence of a large quantity of oxygen in the bladders of deep-swimming marine fishes, it not unlikely has a respiratory purpose, the bladder being, as suggested by Semper, used as a reservoir for oxygen, to serve the fish when sleeping, or when, from any cause, not actively breathing. The excess of oxygen is not due to any like excess in the gaseous contents of sea-water, for the percentage of oxygen decreases from the surface downward, while that of nitrogen remains nearly unchanged. In all cases, indeed, the bladder may preserve a share of its old function, and act as an aid in respiration. Speaking of this, Cuvier says: "With regard to the presumed assistance which the swim-bladder affords in respiration, it is a fact that, when a fish is deprived of that organ, the production of carbonic acid by the branchiæ is very trifling," thus strongly indicating that the bladder still plays a part in the oxygenation of the blood.

Under the hypothesis here presented, the process of evolution involved may be thus summed up. Air-breathing in fishes was originally performed by the unchanged walls of the œsophagus, perhaps at specially vascular localities. Then the wall folded inward, and a pouch was finally formed, opening to the air. The pouch next became constricted off, with a duct of connection. Then the pouch became an air-bladder with respiratory function, and finally developed into a simple lung. These air-breathing fishes haunted the shores, their fins

becoming converted into limbs suitable for land locomotion, and in time developed into the lung- and gill-breathing batrachia, and these in their turn into the lung-breathing reptilia, the locomotor organs gradually increasing in efficiency. Of these pre-batrachia, we have existing representatives in the mud-haunting Dipnoi, with their feeble limbs. In the great majority of the Ganoid fishes the bladder served but a minor purpose as a breathing organ, the gills doing the bulk of the work. In the Teleostean descendants of the Ganoids the respiratory function of the bladder in great measure or wholly ceased, in the majority of cases the duct closing up or disappearing, leaving the pouch as a closed internal sac, far removed from its place of origin. In this condition it served as an aid in swimming, perhaps as a survival of one of its ancient uses. It gained also in certain cases some connection with the organ of hearing. But these were makeshift and unimportant functions, as we may gather from the fact that many fishes found no need for them, the bladder in these cases decreasing in size until too small to be of use in swimming; and in other cases completely disappearing, after having travelled far from its point of origin. In some other cases, above cited, the process seems to have begun again in modern times, in an eversion of the wall of the œsophagus for respiratory purposes. The whole process, if I have correctly conceived it, certainly forms a remarkable organic cycle of development and degeneration, which perhaps has no counterpart of similarly striking character in the whole range of organic life.

SOME USES OF BACTERIA.

By Dr. H. W. Conn.

(*Continued from Vol. XXVI, page 911.*)

I may now pass to the third branch of my subject and speak of the use of bacteria as scavengers in the world. A tree in the forest falls to the ground and it lies unmolested. It is at first hard, solid and impervious to all of the normal agencies. No insects can touch it; they cannot bite the hard wood to any extent. It lies there month after month. Little by little it begins to soften.

First the bark begins to get soft and finally falls off. By-and-by the wood gets quite soft, so that you can easily cut it, and perhaps run a pointed stick into it. Then insects get hold of it, and they begin to eat it; they bore tunnels and begin to crawl through it. The tree grows softer and softer, and finally, as you all know from observation many times, the trunk of this tree becomes softened into a mass of brown powder which sinks down into the soil and disappears. What has become of that tree? A bird dies and falls on the ground, and unless some animal comes along to eat the bird you will notice that the tissues of the bird very soon begin to undergo changes; they begin to soften; gases rise from them; the flesh of the bird undergoes the process which we call putrefaction, and that putrefaction results in the gradual decomposition of the tissues. Little by little part of the material passes off into the air as gas, and the rest of it sinks down into the soil and the bird disappears. What has produced all of these changes? Did it ever occur to you to ask what the condition of the surface of the earth would be at the present time if it were not for these processes which we call the processes of decay? Suppose there were no agencies which caused the gradual softening and destruction of trees and the dead bodies of animals. Long since the vegetable and animal life of this world would have disappeared, and we should have had the surface

of the earth covered with the accumulations of the growth of forests in past ages that would have tumbled upon each other until there would be such an accumulation of dead trees and dead leaves and dead vegetation of all kinds on the surface of the earth that plants would not be able to grow. The dead bodies of all the animals that have lived in the past would have been piled up until the whole surface of the world would have been so covered by the dead bodies of animals and plants that life would have become impossible. These scavengers, these bacteria, are absolutely necessary to us. It is through the agency of certain bacterial organisms that the tree is softened so that insects can get at it. It is through the agency of bacteria that the tissues of the bird are decomposed and gases produced which pass off into the air. It is these bacteria which cause all the changes in the bodies of animals and vegetables, decomposing them until they gradually sink down in the soil and disappear. So it is through their agency and this alone that the surface of the earth is kept in a condition which renders it possible for life to continue to exist. Of course you have all had experience of the value of bacteria as scavengers in removing bad odors. We speak of scavengers as of value in removing decaying material, but it is the bacteria which produce the decay, and it is through their agency that all of these dead bodies are broken to pieces and brought into a condition in which they can be either incorporated into the soil or passed off into the air.

Perhaps I may here also say a word in regard to the agency of bacteria as scavengers in the human body. We look upon bacteria in our bodies as causes of disease rather than things which are of any value, and yet a healthy person always has bacteria in large quantities in his mouth, in his stomach, and in his intestines. The bacteria are always migrating in the body to places of abnormal growths, and there is considerable reason for thinking that to a certain extent these bacteria act as scavengers in the human body. Some of them unquestionably act as producers of disease, but to a certain extent it seems that these bacteria are of a value in assisting in the decomposition of tissues that should be decomposed, and there

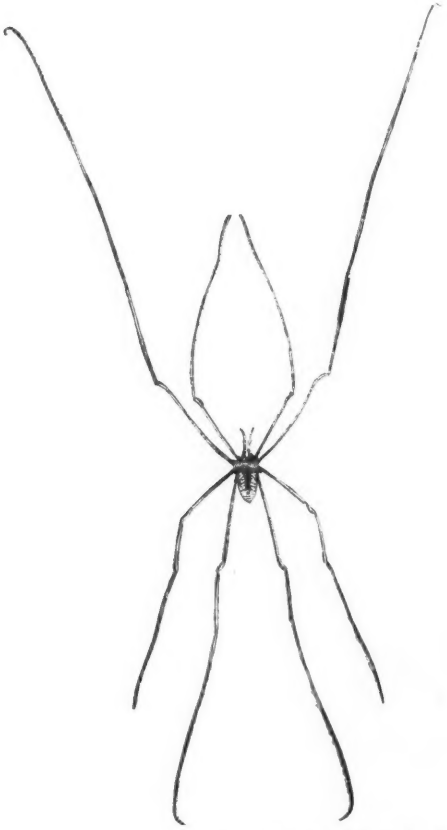
is reason for thinking that they assist in the digestion of food. There is no question that bacteria *may* assist in the process of digestion and it is doubtless a fact that the bacteria which we take into our alimentary canal are not wholly injurious. They may be possibly beneficial to us either in the line of scavengers in removing material which ought not to remain in our bodies, or in assisting digestion. This point, however, is not yet demonstrated, and I merely allude to it as a possibility.

Did it ever occur to you to ask why nature is perpetual? You know animals and plants have continued to live on the surface of the earth for hundreds and hundreds of centuries. The vegetation that has been growing on the surface of the earth has been constantly taking food out of the air and taking food out of the soil, and animals have been constantly feeding upon the plants. But the process seems to be a never-ending one. It would seem that the material for plant food and animal food would sometime be used up; and yet nature is perpetual. Now, the reason that nature is perpetual is, because animals and plants are enabled, by certain processes of nature, to use the same material over and over and over again. They can use material for food, and eventually that same material gets in a condition in which they can use it for food once more. Let me take a single illustration, one that you are probably all familiar with. Plants, as the result of their life, use up carbonic acid of the air, and, in return, send off into the air an equivalent amount of oxygen. Now, animals in their life, take out of the air a considerable amount of oxygen and send off from their bodies an equivalent amount of carbonic acid. You see here one of the adjustments of nature. Animals use the excretions of plants, plants use the excretions of animals. The animals take oxygen and give off carbonic acid, and the plants take carbonic acid and give off oxygen. This process goes on continually and thus the condition of the atmosphere, so far as oxygen and carbonic acid are concerned, is kept in the same normal state. Thus, so far as these gases are concerned, nature is enabled to be

perpetuated by the constant use of the same material over and over again.

Now, this is not only true in regard to oxygen and carbonic acid, but it is true also that all the other foods of animals and plants are capable of being used over and over again. Plants live upon phosphates, sulphates, and nitrates chiefly, as well as carbonic acid. Animals live upon such things as albuminoids and starches and sugars. Now, plants cannot live on the food of animals, and animals cannot live on the food of plants. You and I cannot live upon sulphates and phosphates and potassium salts and nitrates and carbonic acid. These are what we call inorganic compounds in nature. Animals cannot feed upon them, but plants can do so. The plants can take those materials and manufacture out of them the starches and sugars and fats and albuminoids, and then we can take the starches and sugars and fats and albuminoids which have thus been manufactured for us and feed upon them. You see, therefore, that the plants serve as a medium of communication between animals and nature. The world is made up chiefly of inorganic compounds like these phosphates and sulphates and potassium salts, etc., and the plants serve as a means of communication between animals and the inorganic world, for the plants take these inorganic materials and make them into something which we can use as food. Plants, then, are the means which we have of making use of inorganic nature; or, in other words, the whole animal kingdom is parasitic upon plants. But plants are in their turn utterly unable to live upon animal foods. A plant cannot feed upon albumen, a plant cannot eat starch, a plant cannot eat sugar, a plant cannot eat fat; plants are unable to use the foods that animals use, and when the body of a plant dies, although it is in a condition to be used as food by animals, it is not in a condition to be used again as food for plants. The dead body of the bird is in a condition in which plants cannot make use of it at all. A plant cannot use the albumen of the bird's tissue; a plant cannot use the fats in an animal; a plant cannot feed upon the sugars that are in the dead sugar-cane; a plant cannot feed upon the

PLATE XXVII.



Liobunum vittatum Say. Male. Mississippi.

starches or the cellulose that is in the body of the dead tree. Nevertheless, the plants do succeed in getting hold of this food, and it is through the agency of these bacteria that we are speaking of this morning that they do it. Just as soon as the body of an animal or plant dies, the bacteria get into it, begin to grow in it, decomposing it, and pulling it to pieces. They pull the starch to pieces, they pull the sugar to pieces, and albumens and fats share the same destruction. Little by little they take those compounds which plants cannot feed upon, and, by shaking them to pieces, bring them down to simple combinations which plants can feed upon.

Of special importance is one particular kind of organism known as "the nitrifying organism," which produces nitric acid. Plants as I have said, cannot feed upon such things as albumen. The putrefying bacteria can decompose albumen and break it up into certain simple compounds, but ordinary putrefying bacteria are not able to break that albumen down far enough for plants to get hold of it. Plants have got to live upon such things as nitrates and salts of nitric acid. Now, there is one sort of bacteria living in the soil which gets hold of the albuminous compounds and forms nitric acid. This is the nitrifying organism, and the nitrification is the last stage in the decomposition process by which an albuminoid is converted into a condition in which plants can get hold of it. One practical application of this you are all familiar with in the ripening of fertilizers. You know that green manure is of absolutely or of practically no use as a fertilizer on your fields. You know that it must first stand for a while and ripen, or "rot," as you call it. Now, what is taking place in that fertilizer while it is ripening? Simply the series of changes that have been mentioned. That fertilizer contains chemical compounds of a high degree of complexity, compounds that the plants cannot feed upon; they are too highly complex for plants to use as food. Bacteria, however, get into that heap and begin to grow in it; and, as the fertilizer becomes ripened, these high chemical compounds are pulled to pieces, they become converted into simpler decomposition products, and eventually, if the ripening be

continued long enough, the fertilizer is in a condition fit for for the fields. Now, when put upon the fields, the plants can get hold of the material. You will see now what I meant when I stated at the beginning of my lecture that in spite of all the cultivating that you and your horses might do in the fields, it would be useless without the agency of these organisms. You might put on your fertilizer; but, if that fertilizer be not acted upon by bacteria, it will be of no use, and thus the bacteria come in to complete the operation which you began. You do your duty and the bacteria do theirs, and the consequence is, the fertilizers which you are using are brought into a condition in which the plants can get hold of them, and thus the food of plants is produced. You see, then, that in this way plants and animals are able to use over and over again the same material. The plant gets this material out of the soil and out of the air; the animal comes along then and feeds upon the plant; then the animal dies, and the plant dies, and the bacteria get into the body of the animal or plant, pull it to pieces and produce from it decomposition products, and they get into the soil in the form of nitrates and nitric acid compounds; or they go off into the air in the form of ammonia and carbonic acid. The bodies of these animals and plants are thus reduced to simple conditions and now the plants once more get hold of them, and use as food the same material that previous generations used. Thus over and over again the same material is used, and thus nature is kept perpetual. This is the explanation of the constant, perpetual growth in nature. This is the reason that nature does not exhaust itself. This is the reason that animals and plants have been enabled to grow upon the surface of the earth for the past hundreds and hundreds of centuries.

But this is not the end of the agency of bacteria in plant life. They are not only of value in ripening your fertilizers and in keeping up this constant growth of nature, but we have learned within the last two or three years that at the very foundation the growth of plants is absolutely dependent upon these organisms, and similarly in the future the continuance of the vegetable world must be also dependent upon

them. I have stated that nature is perpetual because the same material can be used over and over again. That is true in a sense, but not true completely, for you will see with a little thought that little by little the soil is being drained of its food, little by little the materials in the soil are being turned into the ocean. A tree grows, takes out of the soil its food, and finally dies. If it falls on to the ground, as I have described, the bacteria get at it and grow there until the tree eventually becomes wholly incorporated into soil so that it can be used once more as plant food. But it may be that the tree instead of falling in the forest falls into a river, drifts down the river, begins to decay, and eventually goes into the ocean. After the products of decomposition are passed into the ocean, there is no getting them back to the soil. "The sea will not give up its dead," and the ocean does not give up the nitrogen and the other salts that are gradually being carried to it by this process. Or, again, a plant grows and produces wheat, produces fruit, produces nuts, and the grain, the fruit, and the nuts are taken to the city to be used as food for men. The food is used by men, and most of it eventually gets into the sewage of the city, is carried down to the river, and from the river it is carried into the ocean. So here again through the sewage of our cities, the foods which are supplied to our cities are being thrown into the ocean and thus the soil is being drained of its foods. This process is not a rapid one. It is only slowly that the foods are being taken out of the soil and carried to the ocean. Nevertheless, it is the constant dropping that wears away the rock, and it is easy for us to see that if this process goes on age after age, our souls are inevitably doomed to exhaustion. You know that many fields have become sterile, that many farms have been worn out, that many gardens are becoming infertile. You cannot cultivate your fields as you used to without furnishing them food. In the old world this is quite noticeable. Although the constant drainage of the soil by these agencies is a slow one, it is a sure one, and if there be no way of getting nitrogen and other salts back from the ocean to the soil, it would seem that the life of all vegetation is inevitably doomed to exhaustion, and with

the life of vegetation the life of animals must cease. The whole living world must end.

When the scientist observed this fact he immediately looked around to see if there was not a remedy for it. Now, as far as some of the plant foods are concerned, there does not seem to be any occasion for fear. The phosphates, the sulphates and the potassium salts, which are plant foods, seem to exist on the surface of the earth in almost unlimited quantities. There have been immense amounts of these salts found in certain parts of the world, and they can be mined at very small expense; they can be taken all over the world and put directly upon the soil, so that the sulphates, phosphates and potassium salts are in practically unlimited quantities. We have no fear so far as they are concerned. For an indefinite number of ages to come there is plenty of this sort of food on the surface of the earth for us to supply to the soil. But that is not true of the nitrogenous foods. Of course every farmer knows to-day that nitrogenous food is one of the very essential foods of plants, and it is not true that there is an unlimited quantity of nitrogenous salts anywhere in the world. There are a few sources of nitrogen other than the soil. The chief one is the guano beds in the South Pacific. These are sources of nitrogenous compounds, and upon these sources the agricultural industry of the world has been drawing for years, and will continue to draw until they are exhausted. But these sources are far away. The nitrogen that we get from them is very expensive, and the store is very limited in quantity. We can see in the not very distant future the complete exhaustion of all these nitrogen beds. This has led scientists to look with a considerable degree of dismay upon the future of the vegetable world. What is going to happen when all the available nitrogen is used up? If we are going to continue to take the nitrogen from the soil and throw it into the ocean we will soon exhaust the soil, and if there is no store of nitrogen anywhere for our plants to draw upon what are our plants going to do in the future?

Now there is a store of nitrogen in the world which is absolutely unlimited, and that is in the air that surrounds us. The

air that we breathe is made up of four parts of nitrogen and one part of oxygen. There are quantities of nitrogen everywhere if the plants could only get hold of it, but it has been thought that plants cannot feed on the nitrogen in the air at all. Experiments have been carried on for a great many years to find out whether plants could not in some way or other get hold of the nitrogen of the air. If we could only prove that our plants can get hold of the nitrogen in the air then the problem is solved. But the experiments which have been carried on year after year have seemed to demonstrate that plants cannot use the nitrogen of the air for food, that it is not in a condition in which they can get hold of it. About ten years ago, however, certain experimenters in this country and in Europe found that in some of their experiments plants did in some way get hold of nitrogen from some source when it was not fed to them; that a plant could be grown in sand absolutely free from nitrogen, and yet in some way that plant got hold of nitrogen; the only source for it was out of the air. That led to further experimentation until within the last four or five years the results have all been pointing in one direction. They seem to show us that there is one family of plants at least, which is capable of getting hold of nitrogen out of the air. This is the plant family to which the pea, the bean and the clover belong. It is, in general, the pea family—the *Leguminosæ* family of plants. This family of plants in some way does succeed in getting nitrogen from some source when we do not give it to them as food, and it must be that they get it from the air. And yet those experiments are entirely contradictory to the earlier experiments which seemed to show that plants could not get hold of nitrogen in the air. The explanation was not found until a few years ago. Two or three years ago some experiments were performed in Germany which have finally led to the solution of the problem, at least in part, and, curiously enough, we find that the whole secret of the matter is connected with these organisms which I am discussing this morning. It is to bacteria that we owe this power which is possessed by plants of the pea family to get hold of nitrogen. If you plant peas in soil containing a cer-

tain species of bacteria, or at least certain species of micro-organisms, these micro-organisms crawl into the roots of the pea, and then begin to multiply inside the roots. The little roots begin to swell and there appear upon them a lot of minute nodules, which have received the name of "root-tubercles." If I am not mistaken some of those little root tubercles were shown to the meeting here last evening. These root tubercles, as I say, make their appearance, and it is found that wherever these root tubercles do make their appearance the plant gets hold of nitrogen and grow well. Where these root tubercles do not make their appearance the plant is unable to get hold of the nitrogen unless it is fed to them. Now these root tubercles are produced by bacteria, and these root tubercles are the agencies by which, in some as yet unexplained way, the pea gets nitrogen out of the air.

Thus you see that in the final analysis of the life of a plant, in the assimilation of nitrogen from the air, we are brought to the conclusion that it is the agency of these minute microscopic organisms that is the source of the assimilation of nitrogen from the air by plants. Thus we owe the growth of these plants to bacteria. How the bacteria get the nitrogen out of the air has not yet been explained.

Even before the scientists made this discovery the farmer had made the discovery practically on his farm. You have known that you could in some, to you inexplicable, way rejuvenate an old, worn-out soil by cultivating clover upon it, or by cultivating beans. That has been the practice of farmers for years. It has been found that in some way the cultivation of clover, instead of exhausting your soil as the cultivation of some plants does, really increases the fertility of the soil. You cultivate your clover for one season, then the next season you plow the roots into your soil, and you find the field will produce a better crop than before. This result is brought about through the agency of these organisms. The clover belongs to the family of peas, and clover is one of the plants that this particular species of bacteria that I am speaking of can attack. The bacteria in the soil get into these roots, grow in them, produce these root tubercles, and by means of these the clover

gets nitrogen out of the air and stores it up in its roots. The next season you plow the roots into the soil, and then come the nitrifying bacteria which pull the roots to pieces and decompose them into the condition of nitrates, and then the next season the plant which you sow gets hold of the nitrates which came from the roots of the clover and which has been brought there through the agency of these bacteria. You see, then, that the farmer owes everything to the bacteria.

I think you will find that I am justified in the statement I made at the beginning that the study of bacteriology to-day is even more truly a department of agriculture than of medicine. The bacteria belong to the farmer more truly, or at least as truly, as they belong to the physician.

Now I must draw my remarks to a close. Let me, in conclusion, say that we must not think too hardly of bacteria. It is true they are the causes of evil, it is true that they produce disease, but it is also true that they do good. It is true that they are our enemies but it is also true that they are our closest allies. It is true that without them we could not have our smallpox nor our yellow-fever, we could not have our diphtheria or our scarlet fever, neither could we have the epidemic which is at present going over this country, nor in fact should we have any of our epidemics were it not for the bacteria. But when we remember that it is through the agency of these organisms that we bake the loaf of bread that comes onto our table, that it is through their agency that the immense brewing industries are able to exist, that it is through their agency that the industries connected with the manufacture of alcoholic liquors are possible; that without them we could not get our vinegar or our lactic acid; that without them we could not make our ensilage; when we remember that these bacteria give the butter-maker the aroma of his butter; when we remember that it is the decomposition products of the bacteria that the cheese manufacturer sells in the market; when we remember their agency as scavengers, how it is that they keep the surface of the earth clean and fresh and pure and in a constant condition for the continued growth of plants; when we remember their value to the soil in decomposing the dead

bodies of animals and plants, and thus enabling the same material to be used over and over again for the support of life, and hence making possible a constant, perpetual condition of nature; and when we remember, lastly, that it is only through their agency that plants were originally enabled to get hold of nitrogen at all and that it is only through the agency of these bacteria that we may hope for a continuance of a supply of nitrogen to the soil, when we remember all these things I think we will recognize that the power of the bacteria for good far outweighs their power for evil. Without them we should not have our epidemics, but without them we should not exist. Without them it might be that some individuals would live a little longer, if we could live at all. It is true that bacteria, by the production of diseases once in a while, cause the premature death of an individual; once in a while they will sweep off a hundred or a thousand individuals, but it is equally true that if it were not for them plant life and animal life would be absolutely impossible on the face of the world.—*Connecticut Agric. Report, 1892.*

THE STRIPED HARVEST-SPIDER: A STUDY IN VARIATION.

By Clarence M. Weed.

In 1821 Thomas Say described in the Journal of the Academy of Natural Sciences of Philadelphia two species of harvest-spiders, one of which he named *Phalangium vittatum* and the other *Phalangium dorsatum.* He stated that the former "inhabits the Southern States" and that the latter "inhabits the United States." His descriptions in both cases were evidently drawn up from specimens not fully matured, and the characterizations are meagre and unsatisfactory. The two species are said to be similar in color, but distinguished from each other by the "terminal joint of the palpi being pectinated with spines" in *P. dorsatum.*

In 1868 Dr. H. C. Wood published extended descriptions of both these species.[1] He states that they are closely related, "the principal characters separating the two being found in the differences in coloration of the dorsum and legs, the trochanter not being black in *P. vittatum,* and the much greater hardness and roughness of the upper surface of the southern species." He adds that *P. vittatum* "may be looked upon as the southern representative of its nearest ally, *P. dorsatum,* of which I have never seen any specimens from farther south than Washington City."

Since Dr. Wood's paper was published I have treated of[2] these species two or three times, taking them out of the old genus Phalangium, and referring them to Liobunum. In 1889 I stated that "after examining hundreds of specimens of *dorsatum* and dozens of *vittatum,* I am unable to find any constant structural character by which they may be separated, though the difference in the size of the body and length of legs is very marked."

[1] Comm. Essex Institute, VI, pp. 18–21.

[2] Amer. Nat., XXI, p. 935; Bull. Ill. St. Lab. Nat. Hist. III, pp. 83–87.

TABLE I. LIOBUNUM VITTATUM SAY. MALE. COLUMBUS, OHIO.

No. of Specimen.	Measurements of body in mm.		Measurements of legs in mm.				Remarks.
	Length.	Width.	1st pair	2d pair	3d pair	4th pair	
1	—	—	33	67.4	34.4	49	Body not measured. Collected 20 Sept., 1889.
2	—	—	33	65.6	34	42.4	" " " 19 " "
3	—	—	34.6	67.6	35	50	" " " 18 " "
4	—	—	31.6	63.4	32	46	" " " 20 " "
5	—	—	35.4	70	35.8	50	" " " 20 " "
6	—	—	35	71	35.6	49	" " " 19 " "
7	—	—	35	70.6	34.6	51	" " " 21 " "
8	—	—	35	72	36	51	" " " 18 " "
9	—	—	34.4	69	36	51	" " " 21 " "
10	—	—	35	67	35.2	49	" " " 18 " "
11	6.2	—	38.8	76	38	54.6	Collected 26 Sept., 1889.
12	6.8	—	35.4	69.8	36	50.6	" " " "
13	6.2	—	35	66.4	35.8	49.6	" " " "
14	5.2	—	39.4	76	40.2	57	" " " "
15	6.4	3	37.4	77.2	38	55	" 2 Oct., " Palpi 6.2 mm. long.
16	5.8	—	33	67.4	33.4	47	" 26 Sept., "
17	8	—	35.4	72.4	35.4	52	" 25 " "
Longest.	8		39.4	77.2	40.2	57	
Shortest.	5.2		31.6	63.4	32	42.4	
Difference	2.8		7.8	13.8	8.2	14.6	
Average.	6.3		35	69.8	35	50.2	

During the last eight years I have collected hundreds of these striped harvest spiders in half a dozen States—some of them widely separated—and have received from correspond-

TABLE II. LIOBUNUM VITTATUM DORSATUM SAY. MALE. URBANA, ILLINOIS.

No. of Specimen.	Measurements of body.			Measurements of legs.				Length of Palpi.	Remarks.
	Length.	Breadth.	Height.	1st pair	2d pair	3d pair	4th pair		
1	5.5	4	3	28	55	27.5	39	6	Collected 9 August, 1887.
2	6	4	3	25	50	26	37	6.7	" " "
3	6	4	3	26.5	54	27.5	40	7	" " "
4	5.5	4	3	25	45	25	34	6	" " "
5	6	4	3	24	46	24	34	6.5	" " "
6	6	4	3	26	51	26	37.5	6	" " "
Longest	6	4	3	28	55	27.5	40	7	
Shortest.	5.5	4	3	24	45	24	34	6	
Difference.	.5	0	0	4	10	3.5	6	1	
Average.	5.8	4	3	25.7	50.1	26	38.9	6.3	

ents many specimens from other localities. After a careful study of the material thus accumulated—aggregating nearly a thousand specimens—I conclude that we have to do with a single very variable species, in which natural selection has

increased the size of body and the length of legs to the southward, and shortened them in the north. The points of difference indicated by Say and Wood prove without value when many specimens are examined.

The harvest-spiders are well adapted for the study and illustration of organic variation. Their long legs are easily measured, and the results can be set down in black and white, with more striking effect than in the case of most invertebrates.

To determine the variability of the species in a given locality I measured seventeen fully developed males taken in the fall of 1889 at Columbus, Ohio. The results are shown in table I:

This shows a striking and constant variation, the longest of the fourth pair of legs being one-third longer than the shortest, and the difference in the other legs being nearly as great.

To determine whether similar variations occurred in other localities, six fully developed males, collected on the farm of the University of Illinois, were measured, with the results shown in Table II:

The fact that there was a difference of ten millimetres in the length of the second pair of legs in the case of six specimens, selected at random, indicates that this amount of variation, at least, is normal to the species in that locality.

Two fully developed males sent by Mr. J. M. Aldrich from Brookings, South Dakota gave the following measurements:

TABLE III. LIOBUNUM VITTATUM DORSATUM SAY. MALE. BROOKINGS, SOUTH DAK.

No. of Specimen	Measurements of body.			Mensurements of legs.				L'n'th of palpi	Remarks.
	Length	Breadth	Height	I	II	III	IV		
1	5	4	2.5	21	34	21	29	6.2	
2	5	3.5	2.3	19	35	19	26	6.1	
Average	5	3.8	2.4	20	34.5	20	27.5	6.15	

In striking contrast to this are the following measurements of two fully developed males from Mr. H. E. Weed, collected at the Mississippi Agricultural College:

TABLE IV. LIOBUNUM VITTATUM SAY. MALE. AGRICULTURAL COLLEGE, MISS.

No of Specimen	Measurements of body.			Measurements of legs				L'n'th of palpi	Remarks.
	Length	Breadth	Height	I	II	III	IV		
1	7	5	3.6	46	90	46	66	7.5	
2	7.5	4.5	3.5	47	90	46	65	7.5	
	7.25	4.75	6.55	46.5	90	46	65.5	7.5	

In Tables III and IV we have the two extremes in the size of the species, so far as my specimens show it. In the presence of these alone one would unhesitatingly decide that they belonged to two well marked species. The fact that in size of body the Mississippi form is nearly one-third larger; and that the first, third and fourth pairs of legs are considerably more than twice as long, while the second pair is nearly three times as long would in the absence of intermediate forms, fully justify such a separation. But a reference to Tables I and II drawn up from specimens taken about half way between Dakota and Mississippi shows that the size of the species in those localities is intermediate between the two extremes, the second pair of legs in central Illinois averaging 50.1 mm. and in central Ohio 69.8 mm. against 34.5 mm in South Dakota and 90 mm. in Mississippi.

The measurements of individual specimens from various localities given in Table V below indicate that the size of body and length of legs varies greatly with the locality, as a rule the body becoming larger and the legs longer as we go southward.

TABLE V. LIOBUNUM VITTATUM SAY. MALES FROM VARIOUS LOCALITIES.

Locality.	Measurements of body.			Measurements of legs.				L'n'th of palpi
	Length	Breadth	Height	I	II	III	IV	
Iowa (Ames).....	—	—	—	—	45	—	—	—
S. Maine (Orono).....	6	3.7	3	32	60	33	44	6
N Illinois (Normal)..	6.5	4	3	31	59	31	45	6.7
N. Ohio (Brooklyn)...	5.5	4	3.1	35	67	35	—	—
S. Ohio (Ironton).....	6	4.2	3	40	82	40	58	6.4
Virginia (Blacksburg)	—	—	—	—	76	—	—	—
S. Illinois (Cobden)...	7	4	—	44	89	45	64	7

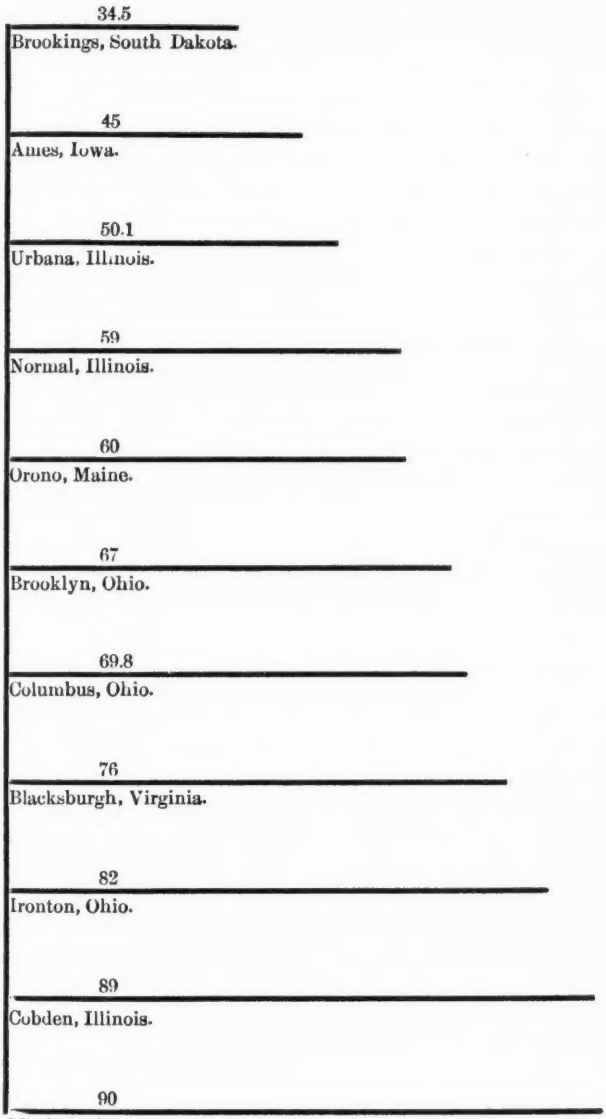
In the diagram on the following page I have reduced the lengths of the second pair of legs of the specimens from all the localities given above to straight lines, each line representing the precise length and the figures above it showing its measurement in millimetres. Where more than one specimen has been measured from a given locality the average is taken. It will be seen that the difference in the progressive lengthening from the north to the south is in no case greater than has been shown in Tables I and II to occur in a single locality. One can find no place where a line can be drawn separating the two forms. Considering in connection with this the fact that there are no structural or colorational differences separating the two, it seems to me evident that, as already stated, we have here a single widely variable species. As the description of *P. vittatum* precedes that of *P. dorsatum* in the original publication, the species should be known as *Liobunum vittatum* (Say) and the northern form as *L. vittatum dorsatum* (Say). It would apparently be well to refer to *dorsatum* the forms from those localities in which the average length of the second pair of legs in the males is less than 70 or possibly 75 mm.

The above records have reference only to the males but a number of measurements of female specimens show that they vary in a similar manner.

Life-History.

This species evidently passes the winter in the egg state as it has never been taken during the winter or early spring months. The eggs of the northern form apparently do not hatch very early, probably not until May, and the young grow slowly. Occasionally I have found a fully developed one during the latter part of June, but generally they do not become mature until July. My collections show two half grown specimens taken at Columbus, Ohio, July 30, 1888, and another collected in the same locality July 16, 1888, which is not fully developed.

When very young these harvest-men seem to prefer the shelter of the grasses, low herbage and rubbish piles, but as they grow larger they are to be found in a great variety of sit-


34.5
Brookings, South Dakota.
45
Ames, Iowa.
50.1
Urbana, Illinois.
59
Normal, Illinois.
60
Orono, Maine.
67
Brooklyn, Ohio.
69.8
Columbus, Ohio.
76
Blacksburgh, Virginia.
82
Ironton, Ohio.
89
Cobden, Illinois.
90
Mississippi.

uations. In the prairie regions of central Illinois, where nearly all of the country is occupied by corn fields and Osage orange hedges, the young are very common on the corn plants, where, as I have elsewhere surmised, they probably live upon the numerous small insects drowned in the moisture contained in the bases of the unfolding leaves, as well as on the corn plant lice (*Aphis maidis*). The full grown individuals are to be found nearly everywhere, on bushes and trees in the woods, in meadows and pastures, along fences, and in sheds and outhouses. They occur abundantly from July to October.

The only opportunity I have had of studying the long-legged southern form in the field was in southern Illinois during the autumn of 1886. Along the rocky ledges running across the State and through Union County, these harvest-spiders were exceedingly abundant, occurring everywhere on the rocks and ground. They were so numerous that as one walked in the open groves on the farm of Mr. Parker Earle they would run along in droves.

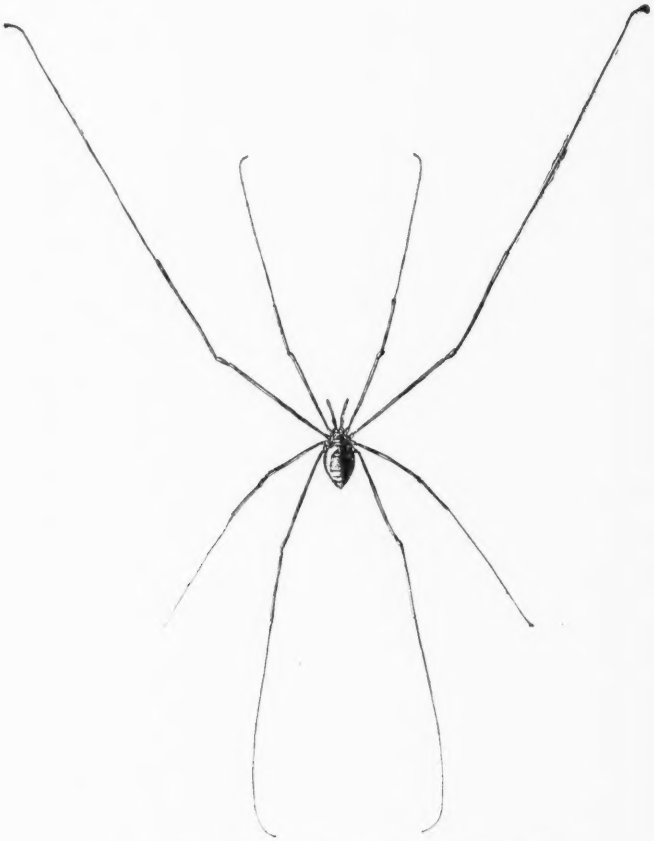
This species, like others of its family has the power of exuding from about the coxæ a liquid with a peculiarly disagreeable odor. This doubtless serves as a protection from birds and other enemies.

An idea of the difference in length of legs between the species as it exists in Dakota and Mississippi may be obtained by comparing Fig. I, Plate XXIX, with Plate XXVII, the first representing a specimen from the former locality, and the second, one from the latter State. The structural details of the two sexes of the southern form are represented magnified at Plate XXIX. In each figure, *a* represents the body with legs detached; *b*, a side view of the eye-eminence; *c*, a front view of the same; *d*, a side view of the palpus; and *e*, a side view of the palpal claw. The row of teeth-like tubercles on the inner border of the last joint of the male palpus do not show in the position from which the drawing was made. The engravings were made from drawings by Miss Freda Detmers.

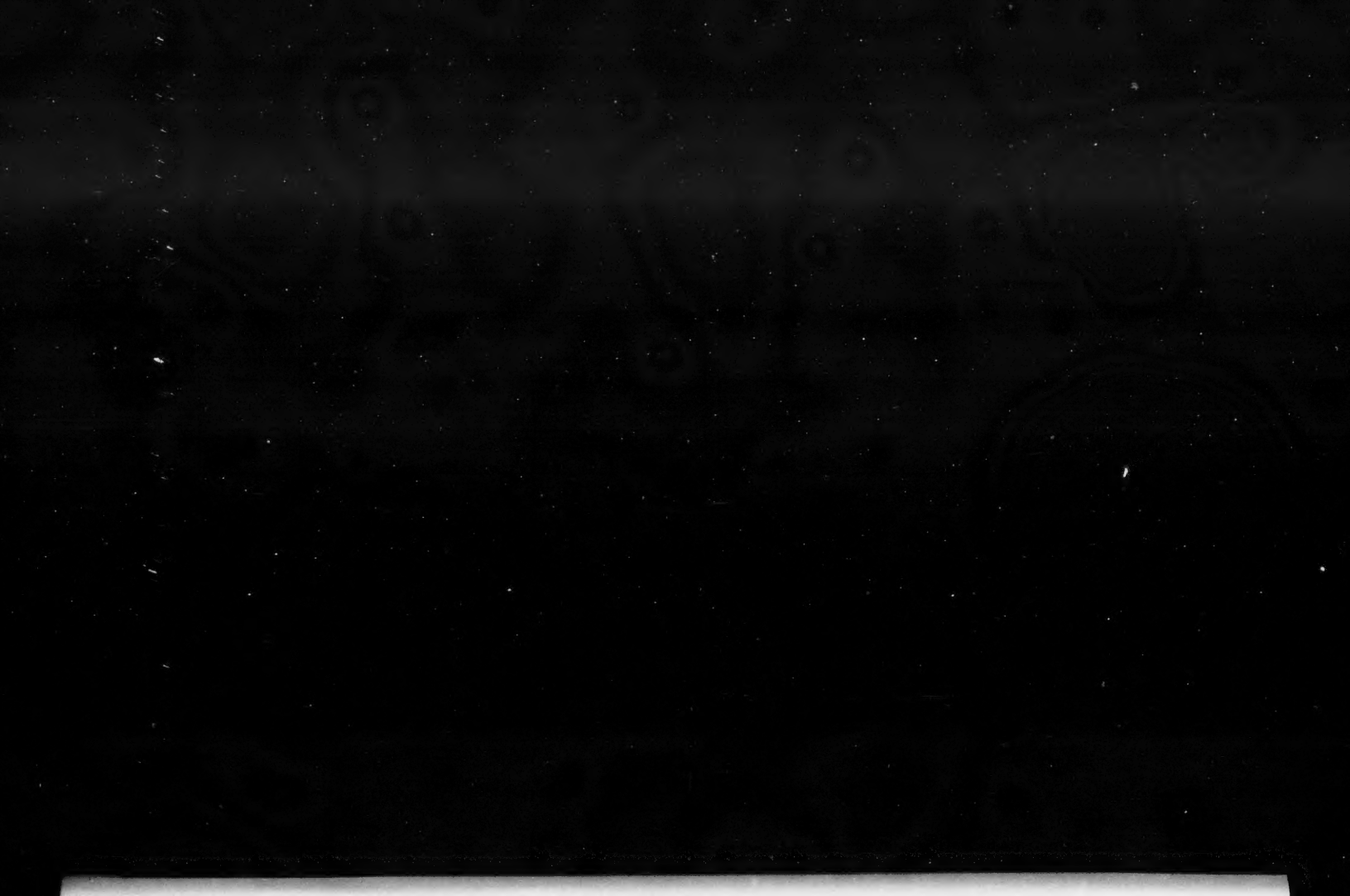
Description.

The southern form of this species may be described as follows:

PLATE XXVIII.



Liobunum vittatum Say. Female. Mississippi.



MALE.—Body 7 mm. long; 4 mm. wide. Palpi 7 mm. long. Legs: I, 44 mm.; II, 89 mm.; III, 45 mm.; IV, 64 mm.

Dorsum reddish-brown, with a dark central marking, commencing at eye eminence and extending backward to the ultimate or penultimate abdominal segment. Contracting slightly near the anterior margin of abdomen, then gradually expanding until about the beginning of the posterior third of the abdomen, where it again slightly contracts. Ventrum slightly paler than dorsum, both finely granulate. Eye eminence a little wider than high, black above, canaliculate, with small black tubercles over the eyes. Mandibles light yellowish-brown, tips of claws black; second joint with short sparse hairs. Palpi long, reddish-brown; tarsal joints paler. Femur and patella arched with two rows of rather blunt dark tubercles on the outer ventro-lateral surface; femur also having a few small subobsolete ones on its dorsal surface. Tibia with a similar row on its outer ventro-lateral surface, a short row on the distal portion of its inner ventro-lateral surface, and a short row on the proximal portion of its ventral surface. Tarsus pubescent, with a row of short, blunt, black tubercles on its inner ventro-lateral surface, extending from the base to near the apex. Legs varying from light brown to black, but patella is generally black and tarsi brown, the other joints varying. Coxæ reddish-brown, minutely tuberculate. Trochanters generally dark brown with minute scattered tubercles. Femora and patellæ with rows of small spines. Tibiæ with very short hairs. Shaft of genital organ slender, subcylindrical, not broadened distally, but bent at an obtuse angle and terminating in a very acute point.

FEMALE.—Body 8–9 mm. long; 5–6 mm. wide. Palpi 5 mm. long. Legs: I, 42 mm.; II, 90 mm.; III, 43 mm.; IV, 61 mm.

Besides its rounder body and much more robust appearance, it differs from the male as follows: Dorsum of a much darker shade of brown with less of the reddish tint, and the ventrum paler. Second joint of mandibles with fewer hairs. Palpi shorter, more slender, with the rows of tubercles on the tibia subobsolete, and that on the tarsus entirely wanting. Legs

generally light brown, with black annulations at the articulations. Ovipositor whitish, with no dark color in the apical rings.

Distribution.

The literature of *L. v. dorsatum* shows that this form occurs in Pennsylvania, New York, District of Columbia, Illinois and Michigan. I also have specimens before me from Iowa (Gillette), Ithaca, New York. (Comstock and Banks), Lincoln, Nebraska, (Bruner), Maine, (Harvey), South Dakota (Aldrich) and a large number collected in the central and northern counties of Ohio, as well as in Vermont and New Hampshire.

By the original describer the southern form (*L. vittatum*) is said to inhabit the southern States. Dr. Wood reports it from Texas and Nebraska, and I have already reported it from southern Illinois and Kentucky. It also occurs in southern Ohio, where it has been collected in Lawrence County, in August, 1888, and July and September, 1889, and in Warren County, where we took it during the summer of 1889. I have also received a number from Arkadelphia, Arkansas, collected in 1887; and Mr. Theodore Pergande has kindly sent me a number collected at Marshall Hall, Maryland, August 21, 1887. Prof. W. B. Alwood has added a few taken at Blacksburg, Virginia, and my brother, Howard Evarts Weed, has sent a large number from Mississippi.

New Hampshire College.

WHAT IS AN "ACQUIRED CHARACTER?"

By C. C. Nutting.[1]

During the discussion of an exceedingly interesting paper on the "Heredity of Acquired Characters," read before the Biological Section of the American Association for the Advancement of Science at its recent meeting, one of the members had the temerity to confess that he was not sure that he knew the exact nature of an "acquired character;" and it was noticeable that none of the noted biologists present on that occasion accepted the implied challenge by an attempt to define the expression which constituted the basis of the debate in which they were engaged. Perhaps it seemed unnecessary to define words that have of late been so prominently and persistently before the biological world. Doubtless most of the persons present, and honesty demands that I count myself among them, felt perfectly competent to give the desired definition; but after a re-survey of the controversy, which has of late made such an unusual demand upon printer's ink, it has become evident to me that the meaning of "acquired character" is elastic to an amazing degree, capable of marvellous contraction or expansion to suit the individual needs of any and all controversialists, be they NeoDarwinian or NeoLamarckian.

But the contractibility of the term is the phenomenon most apt to excite the admiration of the unbiased observer. Weismann himself, the great founder and able exponent of NeoDarwinism, has demonstrated this contractibility along with his exposition of the continuity of the germ-plasm. He says:

"If every new character is said to be 'acquired,' the term at once loses its scientific value, which lies in the restricted use." ——"Science has always claimed the right of taking certain expressions and applying them in a special sense, and I see no

[1]State University, Iowa City, Iowa.

reason why it should not exercise this right in the case of the term 'acquired.'"[2]

"It is certainly necessary to have two terms which distinguish sharply between the two chief groups of characters—the primary characters which first appear in the body itself, and the secondary ones which owe their appearance to variations in the germ, however such variations may have arisen."

He calls the former acquired or "*somatogenic*," and the latter "*blastogenic*," and maintains that "the *somatogenic* characters cannot be transmitted," or, rather, that "those who assert that they can be transmitted must furnish the requisite proofs." "The *somatogenic* characters not only include the effects of mutilation, but the changes which follow from increased or diminished performance of function, and those which are directly due to nutrition and any of the other external inflences which act upon the body."[3]

Here, then, we have Prof. Weismann's definition of acquired characters which are not transmitted, and it would seem to be sufficiently definite. Now, note the process of contraction. Speaking of the source of the variation in the germ, he says:

"I believe, however, that they (the variations) can be referred to the various external influences to which the germ is exposed before the commencement of embryonic development. Hence we may fairly attribute to the adult organism influences which determine the phyletic development of its descendants. For the germ cells are contained in the organism, and the external influences which affect them are intimately connected with the state of the organism in which they lie hid."[4]

Professor Weismann, by the way, concedes that a *quantitative* variation of the germ is thus brought about. "I must confess

[2]Essays upon Heredity, August Weismann. Page 425.

[3]According to this definition, the increased toleration of a high temperature, shown by the bacteria in Dr. Dallinger's experiments, would be an acquired character, and that this character was transmitted was experimentally proven. In the discussion of the paper, however, Prof. Morse claimed that the toleration of unwonted temperature was due to *natural selection, pure and simple*, a position which it is not the purpose of this article to combat. A forcible illustration of the difficulty treated of in the following pages.

[4]Essays on Heredity, Weismann. Page 105.

my inability to see why this variation is not *qualitative* as well."

Are not the qualities of organs and tissues affected by external conditions, such as quality of food, temperature, etc.? What justification can be found for maintaining that the germ cell is the only cell in the body not thus affected, after having admitted that quantitative effects are thus produced? This concession of a quantitative modification of the germ cell by external conditions, acting through the soma, throws the burden of proof that *qualitative modifications are not likewise effected* entirely on the NeoDarwinian side of the controversy.

But these determining causes which "modify the phylogeny of descendants," and hence the descendants themselves, produce modifications which Professor Weismann considers "blastogenic,"[5] although expressly described as acting by external stimuli through the soma. Hence the Lamarckians cannot use any examples of the manifest of modifications brought about in this way, as, although the changes brought about are *somatogenic* by definition, they are *blastogenic* by the *a priori* NeoDarwinian argument. In other words, as soon as a somatogenic variation is inherited it is immediately relegated to the list of blastogenic variations by the NeoDarwinians.

The argument could be put in this way, according to Weismann. "The obvious means by which all inheritance of all transmitted peculiarities takes place is the continuity of the germ plasm."

Any peculiarity thus inherited is blastogenic.

Ergo, any peculiarity which is inherited is blastogenic. As soon as any character, however obviously acquired, is proven by the Lamarckians to be inherited, the NeoDarwinians complacently pronounce that character blastogenic, or not acquired. And so it comes to pass that no acquired character can satisfy the requirements of the case, if that character is so unfortunate as to be transmitted.

[5] "We have an obvious means by which the inheritance of all transmitted peculiarities takes place, in *the continuity of the substance of the germ-cells or germ-plasm.*" (Weismann) P. 105.

A large number of concrete examples of this phenomenon can be found in the works of Weismann and his followers.

A cow which lost its left horn by suppuration afterward produced two calves with a rudimentary left horn in each case. The loss of the horn would certainly be supposed to be an acquired character, but this character was transmitted to two calves, and thus becomes blastogenic to suit the argument. "The loss of the cow's horn may have arisen from a congenital malformation,"[6] and is, therefore, not an acquired character. How a malformation, *due to suppuration*, can be *congenital* is a question not at all considered. The needs of the NeoDarwinian school demand that this malformation be congenital, and therefore a congenital malformation it is.

The young pointer dog, untrained and without any example to imitate, springs forward, barking, at the first report of a gun. "This," say the Lamarckians, "is surely the inheritance of an acquired character;" but, no:—The dog has simply "inherited a reflex mechanism, which impels him to start forward on hearing a report,"[7] instead of running away at full yelp as a common cur would do.

A cat was said to have lost her tail by a cart running over it, and her progeny were tailless. This would seem to be a clincher, but "they, (the rudimentary tails) might have been transmitted from the unknown father."[8]

A soldier loses his left eye by inflammation fifteen years before marriage, and afterward has two sons with defective left eyes. A case of inheritance of an acquired character? Not a bit of it. "The soldier did not lose his left eye because it was injured, but because it was predisposed to become diseased from the beginning!"[9]

A boy's thumbs are malformed by chilblains, associated with some skin disease. Two of his children and two grandchildren have malformed thumbs on both hands. Here we would feel reasonably certain that our search for an acquired

[6]Essays on Heredity. (Weismann) P. 82.

[7]Essays on Heredity. (Weismann) Page 94.

[8]Essays on Heredity. (Weismann) Page 439.

[9]Essays on Heredity. (Weismann) Page 451.

character has been at last rewarded; but no;—"A high degree of susceptibility of the skin of the thumb was obviously innate in the father, and this "*susceptibility*" was what was "certainly transmitted, and led to the similar malformation of the thumbs of the children."[10]

Artificially produced epilepsy in guinea pigs was inherited by the descendants to the fifth generation, but, "it is easy to imagine that the passage of some specific organism (from the lesion made by the division of the sciatic nerve!) through the reproductive cells may take place."[11]

Westphal produces inheritable epilepsy by blows upon the head, and Ziegler asks if the guinea-pigs operated on "may not have been already predisposed to disease?"[12]

But enough examples have been given to demonstrate that acquired characters, however evident they may be to all but the NeoDarwinians, have the convenient property of becoming blastogenic, or not acquired, whenever they are proved to be transmitted.

To what, then, shall we liken an acquired character? To an unstable chemical compound, a vanishing quantity, a will-o'-the-wisp, a name to conjure with! And the Neo-Lamarckians are but children chasing rainbows, which are conjured away in smiling complacency by the wise NeoDarwinians of this generation.

[10]Essays on Heredity. (Weismann) Page 451.

[11]Essays on Heredity. (Weismann) Page 82.

[12]Organic Evolution. (Eimer) Page 182.

EDITORIALS.

EDITORS, E. D. COPE AND J. S. KINGSLEY.

—THE Association of Colleges in New England is taking a good step in its discussion of the following proposed changes in the courses of study in the grammar schools:

1. The introduction of elementary natural history into the earlier years of the program as a substantial subject, to be taught by demonstrations and practical exercises rather than from books.

2. The introduction of elementary physics into the later years of the program as a substantial subject, to be taught by the experimental or laboratory method, and to include exact weighing and measuring by the pupils themselves.

3. The introduction of elementary algebra at an age not later than twelve years.

4. The introduction of elementary plane geometry at an age not later than thirteen years.

5. The offering of the opportunity to study French, German, or Latin, or any two of these languages from and after the age of ten years.

As it has been in the past, the whole course of instruction in the much-praised New England common schools has been such as to repress the individuality and to discourage the observational powers of the pupil. The curriculum has apparently been devised to teach a lot of difficult arithmetical puzzles of no practical value and to encumber the young minds with a lot of abstruse grammatical rules which they must learn, parrot-like, but which they cannot understand until they are more mature. So to gain time for these new subjects, surely as valuable to the ordinary person as cube root or the rules of prosody and the definition of "a conditional, subjunctive, dependent sentence," it is proposed to take from the time usually allotted to arithmetic, geography, and grammar.

That the change will be made without considerable opposition is not to be expected, for the present teachers of our grammar schools are not prepared to teach by the observational method. Were it merely demanded that the instructor should hear the students repeat by rote the statements in some trashy "Fourteen Weeks" text book, there would be little trouble. They could handle that as they do the

drunkard-stomach physiology; but experimental work demands more training and more brains. The new curriculum demands better trained teachers, it provides more practical information for the student; and when we remember that the majority of our children leave their schools behind at the close of the grammar school grade, the necessity of some such change as that here outlined is self evident.

This subject of increase in the scope of our lower schools is attractive, and when upon it one scarcely knows where to stop. Custom and incompetency have forced so many things upon us and inertia so maintains them as they are that a change is a matter of the greatest difficulty. Yet everyone who has studied carefully even the so-called pattern schools of the larger cities of Massachusetts sees that they occupy an enormous amount of time with ridiculously small results. They regard the infantile mind as so much plastic material which must be pressed into a conventional mold and the time necessary for this shaping is regulated by that of the dullest intellects. The children are drilled in the spelling of words like phthisic, and eleemosynary, which they will never have occasion to use until they arrive at years of maturity, and they are kept at the simple problems of addition and multiplication until they are perfect in them, utterly regardless of the fact that this perfection is to be obtained only through practice, and that this practice is to be had in abundance in all the subsequent arithmetical work. Time enough can be gained right here for the insertion of some observational science without the omission of a single useful principle or fact.

Whether it is actually so, or whether it is one of the fictions of our national pride, we are given to regarding the youth of the United States as intellectually the equals of those of any other nation, but it is a mortifying fact that when we compare our children with those of an equal age trained in the schools of Germany and France ours are the sufferers. These foreigners know more things and they know them more thoroughly. They have, at the close of the grammar school grade, not only a knowledge of the "three R's," but they have a grounding of at least one language, and they know besides, the elementary principles of several sciences. The writer believes that with proper instruction our children can equal them, even with our absurdly difficult orthography, and he welcomes this step on the part of the Association as in the right direction.

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RECENT LITERATURE.

The Speech of Monkeys.[1]—For a number of years Mr. R. L. Garner has been engaged in a series of observations and experiments with a view of proving the truth of his theory that monkeys possess an articulate language comparable with that of man. Thinking that his investigations may be of interest and perhaps induce others to take up a similar line of work, he has published in a small volume of 217 pages a report of his progress. The author first gives in detail a number of experiments to illustrate his method, and secondly, a definition of speech followed by the deductions made from his experiments.

Mr. Garner's general plan of procedure is to obtain phonographic records of sounds made by monkeys under varied stimuli. These records were studied with care by Mr. Garner until he could recognize and perfectly imitate many. Having accomplished this the next step is to repeat the sound to the monkey and observe its effect on its action. In this way Mr. Garner has determined with a fair degree of certainty nine sounds used by the Capuchins, and also the sound for food, and the sound of alarm in the Rhesus dialect. The following is one of many experiments to decide the meaning of the sound supposed to mean milk in Capuchin language:

"On one of my visits to the Chicago garden I stood with my side to a cage containing a small Capuchin, and gave the sound which I have translated "milk." It caused him to turn and look at me, and on repeating the sound a few times he answered me very distinctly with the same, picking up the pan from which he usually drank, and as I repeated the word he brought the pan to the front of the cage, set it down and came up to the bars, and uttered the word distinctly. I had not shown him any milk or any kind of food; but the man in charge, at my request, brought me some milk, which I gave to him. He drank it with great delight; then looked at me and held up his pan, repeating the sound. I am quite sure that he used the same sound each time that he wanted milk. During this same visit I tried many experiments with the word which I am now convinced means "food" or "hunger."

[1]The Speech of Monkeys, by R. L. Garner, in two parts. New York, 1892. Charles L. Webster & Co., publishers.

Another experiment, satisfactory in its results, tested the sound for alarm or assault. Mr. Garner gives the account as follows:

In Charleston a gentleman owns a fine specimen of the brown Cebus. This monkey is naturally shy of strangers, but on my first visit to him I addressed him in his native tongue, and he really seemed to regard me very kindly; he would eat from my hand and allow me to caress him through the bars of the cage.

He eyed me with evident curiosity, but invariably responded to the word that I uttered in his own language. On my third visit to him I determined to try the effect of the peculiar sound of "alarm" or "assault," which I had learned from one of this species; but I cannot very well represent in letters. While he was eating from my hand I gave this peculiar piercing note, and he instantly sprang to a perch in the top of his cage, thence in and out of his sleeping apartment with great speed and almost wild with fear. As I repeated the sound his fears seemed to increase, until from a mere sense of compassion I desisted. No amount of coaxing would induce him to return to me. I retired to a distance of twenty feet from his cage, and his master induced him to descend from the perch, which he did with the greatest reluctance and suspicion. I gave the sound again from where I stood, and it produced almost the same results as before.

Mr. Garner gives numerous other illustrations of his methods and furnishes a summary of his observations as follows:

The sounds which monkeys make are voluntary, deliberate, and articulate. They are always addressed to some certain individual with the evident purpose of having them understood. The monkey indicates by his own acts and the manner of delivery that he is conscious of the meaning of the sounds. They wait for and expect an answer, and if they do not receive one they frequently repeat the sounds. They usually look at the person addressed, and do not utter these sounds when alone or as a mere pastime, but only at such times as some one is present to hear them, either some person or another monkey. They understand the signs made by other monkeys of their own kind, and usually respond to them with a like sound. They understand these sounds when imitated by a human being, by a whistle, a phonograph or other mechanical devices, and this indicates that they are guided by the sounds alone, and not by any signs, gestures, or psychic influence. The same sound is interpreted to mean the same thing and obeyed in the same manner by different monkeys of the same species. Different sounds are accompanied by different gestures, and produce different results under the same conditions. They make

their sounds with the vocal organs, and modulate them with the teeth, tongue and lips. The fundamental sounds appear to be pure vowels, but faint traces of consonants are found in many words, especially those of low pitch.

The experiments made by Mr. Garner have been conducted in an ingenious and careful manner, and his results appear to be of value to science. He has the spirit and capacity of the original investigator, and his researches are of much interest to the specialist as well as to the general reader. It is when he turns to the large questions outside of his immediate field of research that it is evident that he has not yet mastered the achievements of human thought. This he will probably do in future, as he has a clear idea of the problems involved. A judicious use of the scissors would have benefited the latter half of the book as it is.

Mr.Garner has gone to Africa with the phonograph with the intention of recording the voices of the gorilla and chimpanzee. It may be questioned whether these animals will be as amenable to social intercourse in the wild state as they are when confined behind the bars of a zoological garden. The gorilla, especially, will not treat with the respect they deserve Mr. Garner's efforts to engage in conversation. We, however, wish him success in his enterprise, not only with regard to these, our distant relations, but also our nearer of kin, the Africans of the native tribes.

Elementary Biology[2]—A book written by a teacher for students. The general plan of the work is to familiarize the student with ideas through the medium of facts. In the author's opinion these ideas are best understood when arrived at by the study of concrete types of animals and plants. The types chosen to illustrate a particular grade of organization must be simple. In view of this last principle considerable attention is given to the Protozoa; only a brief reference is made to Hydra and to the sexual process in Penicillium; Nitella is described instead of Chara, and Polygordius instead of the earthworm. In the chapter devoted to the higher groups of animals and plants brief descriptions of types are given in terms of Polygordius and the Fern respectively. As occasion offers special lessons on such subjects as biogenesis, evolution, origin of species, etc., are introduced in order to give a fairly connected account of the general principles of biology.

[2]Lessons in Elementary Biology, by T. Jeffery Parker, B. Sc., F. R. S., professor of biology in the University of Otago, Dunedin, New Zealand, with eighty-nine illustrations; Macmillan and Co., London and New York, 1891.

To us it seems as if the above plan, while admirable in some respects, was open to criticism. Polygordius, for instance, is a simple annelid, and whether that simplicity is primitive or results from degeneration is of secondary moment in a text book of this sort. Our objection would rather rest upon the fact that the worm is not widely distributed and is infrequent, at least in American waters, while the inland student must entirely forego its use in his laboratory work. On the other hand it is well to have this presentation of the features of this simple worm, for it is usually slighted in our text books and in the most recent one, Hertwig's Lehrbuch, it and the group to which it belongs are entirely ignored in the text.

The numerous illustrations are, for the most part, original, and each plate is fully described instead of having appended a mere list of reference letters. A synopsis, an index, and a glossary complete the work.

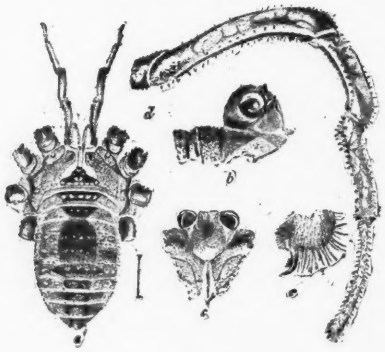
Apgar's Trees of the Northern United States.[3]—The plan of this little book is well indicated in one of the paragraphs in the preface. The difficulty in tree study by the aid of the usual botanies lies mainly in the fact that in using them the first essential parts to be examined are the blossoms and their organs. These remain on the trees a very short time, are often entirely unnoticed on account of their small size or obscure color, and are usually inaccessible, even if seen. In this book the leaves, the wood, the bark, and, in an elementary way, the fruit, are the parts that must be thoroughly known by all who wish to learn to recognize trees. Its purpose is to place before pupils in the public schools an easy manual of our common trees in the hope that the trees of our forests, lawns, yards, orchards, streets, borders, and parks may not continue to be neglected—a most commendable endeavor, indeed.

Doubtless if our teachers of botany in the public schools had anything like an adequate knowledge of the subject such a book would not be called for, but as Prof. Apgar somewhat sarcastically remarks, "this book was written for the average teacher who has had no strictly scientific training." It is to be hoped that it will serve the purpose intended by its author, and that the next generation of high school graduates, all of whom have "done botany, of course," will know

[3]Trees of the Northern United States, their study, description and determination; for the use of schools and private students, by Austin C. Apgar, professor of botany in the New Jersey State Normal School. Small, 8 vol., 224 pp. American Book Company, 1892.

PLATE XXIX.

Fig. 1.

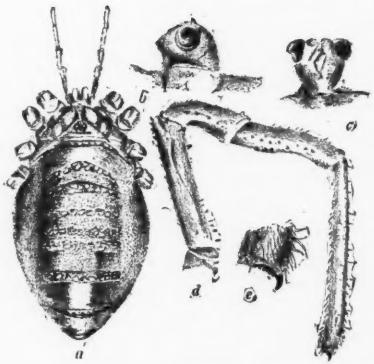


Male.

Fig. 1.

Liobunum vittatum dorsatum. Male. Dakota.

Fig. 2.



Female. *Liobunum vittatum Say.*

something of our common trees. It can be heartily commended to horticulturists, gardeners, and non-botanical tree planters.

The illustrations are helpful, and are apparently quite accurate. The nomenclature is strictly that of the latest edition of "Gray's Manual," an error of judgment which can easily be corrected in a subsequent edition.—CHARLES E. BESSEY.

Bailey's Rule Book.[4]—Although not strictly a botanical work, this little book contains a good deal of botany, and very good botany, too. It should be in the teacher's library, in the public schools, where nearly every chapter, non-botanical as well as botanical, will be instructive. The chapters on Plant Diseases, Fungicides, Weeds, and Moss, Seed Tables, Collecting and Preserving, Names, Histories, and Statistics, are those dealing more especially with botanical topics. Under the first-mentioned topic are given in summary form such descriptions of the general appearance of many of the fungi parasitic upon common plants as will enable anyone to recognize them. For horticulturists this chapter will be most helpful, but it will be scarcely less so for many a teacher of botany who is obliged to get on with a small library, especially as to works on the fungi.—CHARLES E. BESSEY.

Brehm's Thierleben, Kriechthiere und Lurche.[5]—The third edition of this well-known work, under direction of Professors Oscar Boettger and Pechuel Loesche, brings it up to the present date and adds to its previous well-earned reputation. The authors, as was to have been expected, dwell relatively more upon European species than upon those exotic to that country, but the small number of these does not materially disturb the balance of the book except in the department of the true Salamanders, where but one non-European species is figured. The descriptions of the habits of reptiles and batrachians are derived from the best sources, and indeed this work is the only one which is comprehensive and modern in this department, which may be regarded as trustworthy. The illustrations, from the incomparable pencil of Mützel, are the best ever offered to the public in so cheap a

[4]The Horticulturalist's Rule Book, a compendium of useful information for fruit growers, truck gardeners, florists, and others, completed to the beginning of the year 1892, by L. H. Bailey. Second edition revised. 12mo., 215 pp. Rural Publishing Co., N. Y.

[5]Dritte gaäzlich neuaubeitete Auflage; herausg. v. Prof. Pechuel Loesche. Kriechthiere u. Lurche, neubearbeitet von Prof. Dr. O. Boettger u. Prof. Dr. Pechuel Loesche. Leipzig u. Wien Bibliogr. Inst., 1892.

form. The name of Dr. Boettger, of Frankfort a. M., guarantees the scientific accuracy of the treatment. We only notice that he has allowed the *Heloderma suspectum* to be figured as *H. horridum*, and that *Cyclura nubila* to be figured as *C. carinata*. A peculiarly effective picture is the chromo-lithograph representing a species of Draco capturing a butterfly in a tropical forest, with an orchid full of bloom in the foreground, all presenting mimetic colors, and relieved by a background of the symmetrical leaves of a Musa. We reproduce two of the plates, the alligator-crocodile of West Africa, and the snake-necked turtle of the La Plata.

Some interesting comments are made on the abundance of and danger from venomous snakes in tropical countries. It is pointed out that travelers agree that these animals do not constitute a serious obstacle to the comfort and safety of travel in those regions. The author of this work believes that the official reports of deaths from venomous snakes in India are gross exaggerations. If true, he observes, that as compared with snakes, tigers and wolves are harmless creatures. He also believes that in order to obtain the bounty paid for venomous snakes by the Indian Government, a number of establishments for breeding them must be kept in active operation by the natives. None of the citations from travelers indicate a greater abundance of poisonous snakes in tropical countries than we have ourselves observed in the central and southwestern parts of North America.

General Notes.

GEOLOGY AND PALEONTOLOGY.

American Devonian Fishes found in Belgium.—An examination of M. Lohest's collection of Devonian fishes at Liege by Mr. Newberry has brought to light the following interesting facts:

Among the specimens collected in the macignos of Ouppet near the upper part of the sands of Condroz, Mr. Newberry recognized the bony plates of the head of a fish of the genus Dinichthys, which, until now, was found only in America. The genus Dinichthys was created by Newberry for a gigantic fish, with a head a meter in length, having the body like that of Coccosteus covered with bony plates.

Of the specimens recognized by Newberry one was referred to *D. pustulosus*, while the others seemed to be closely allied to the American species, *D. terrilli*.

These fossils were found at Ouppet in a calcareous macigno rock, associated with *Spirifer disjunctus* and also with the palatine teeth of Dipnoans, of which two species, *Dipterus flabelliformis* and *D. nelsonii*, are American types.

The paleontological interest of the presence of Dinichthys in the Devonian of Belgium is increased by the fact that in America these huge creatures are found in a rock analogous to that of Ouppet, associated with the same *Spirifer* and the same *Dipterus*.

In America, also, these fossils are found in a Chemung stratum which is separated from the Lower Carboniferous by a bed of Catskill sandstone containing *Holoptychius americanus*, a species related to the Holoptychius of the famennien of Belgium.

Another Devonian fish described by M. Lohest and referred by him to the genus Bothriolepis, was found near Chèvremont. The fossil shows the head, the swimming organs, and the dorsal plates. It appears to be closely related to *B. canadensis* from the Upper Devonian of Scammenac Bay, Canada.

The discovery in the sands of Condroz of species closely related, if not identical, with American species, confirms the view now generally adopted as to the famennien age of the Chemung and Catskill beds.—Ann. Soc. Geol. de Belgique, Tome xvi.

The Geology of Borneo.—Posewitz treats of the geology of Borneo under four heads: (1) The Mountain-land; (2) The Tertiary Hill-land; (3) The Drift of the Plains; (4) The Alluvium of the Marshes.

The mountain-land consists of crystalline schists, old eruptive rocks, and a slate formation that may be Devonian, overlaid by a carboniferous formation of hard, bluish limestone, succeeded by coarse white sandstones. This carboniferous formation is clearly marked off from the tertiary beds that succeed it.

Cretaceous rocks have been discovered in West Borneo by Van Schelle, the fossils of which have been referred by Geinitz to the Upper Chalk.

The hill-land forms a belt around the mountain-land. It rises into hills (Eocene) near the mountain border and dies away into the common level of the plains (Miocene).

Verbeck divides the Eocene of Borneo into three stages: (a) Sandstone, (b) marl, and (c) the limestone. Of these the sandstone stage is the most important since it contains the Borneo black coal. The marl stage is very fossiliferous, one bed being literally packed with Orbitoides and Nummulites. The limestone stage appears to be the equivalent of the Nummulitic Limestone of Europe.

The eocene strata are pierced in numerous places by the eruption of andesitic lavas probably of miocene age. These lavas are bedded and accompanied by tuffs. Above the andesites lie a series of shales and limestones described by Verbeck as miocene.

The drift of the plains forms a zone round the hill-land, and also covers the flanks of the mountains. It contains the chief deposits of gold, platinum, and diamonds.

The alluvium of the marshes has a wide distribution, owing to the very gradual rise of the land from the coast.

Wallace regards the Malay Archipelago as having been produced by the breaking up of a continental area; Posewitz, on the contrary, describes Borneo as resulting from the fusion of an archipelago of small islands, the grouping of which has been preserved in the main features of the present structure.—Natural Science, April, 1892.

Phosphates and Marls of Alabama.—The interest in the natural fertilizers of the State of Alabama has led Mr. E. A. Smith, the State geologist, to publish a separate bulletin upon the subject in advance of the general report upon the cretaceous and tertiary formations.

The subject is treated with the characteristic thoroughness of the author. The geological age, mode of occurrence, composition, and probable origin of the phosphates are given, followed by remarks on the calcareous marls. The paper closes with a dissertation on the economical relations of the phosphates. Phosphatic marls have been found at the base and summit of the rotten limestone of the cretaceous formation, and in the lignitic, white limestone and Claiborne group of the tertiary. They are not of so high grade as those of South Carolina, but resemble more nearly those of New Jersey. This the author considers to be advantageous to the State. If they are not rich enough to export there is more probability of their use at home; and the enhancement in the value of the lands and the increase in the crops due to their use will represent a larger amount of capital than would the trade in the exported rock.

Keyes' Mississippian Section.—Mr. Charles Keyes substitutes the term Mississippian for Lower Carboniferous as applied to certain rocks of the Mississippi Valley, and tabulates them as follows:

Mississippian Series.	Kaskaskia group.....	Chester shales.
		Kaskaskia limestone.
		Aux Vases sandstone.
	St. Louis group.....	Ste. Genevieve limestone.
		St. Louis limestone.
		Warsaw limestone (in part; not typical).
	Osage group.....	Warsaw shales and limestone.
		Geode bed.
		Keokuk limestone.
		Upper Burlington limestone.
		Lower Burlington limestone.
	Kinderhook group	Chouteau limestone.
		Hannibal shales.
		Louisiana limestone.

Bull. G. S. A., Vol. 3, 1892.

Geology of the Crazy Mountains.—A description recently published by J. E. Wolff gives some interesting features of the Crazy Mountains of Central Montana. They form an isolated range of the Rocky Mountains rising to the height of 11,000 feet above sea level. A branch of the Yellowstone River has cut a transverse valley, dividing the range into northern and southern halves.

The range lies in a region of nearly horizontal cretaceous rocks. The southern half is characterized by a basin structure, the interior of which is interrupted by dome-shaped uplifts of dioritic stock. The

dioritic stock as well as the adjacent cretaceous rocks, are cut by later vertical dykes having a general radial arrangement with the dioritic mass as an approximate center. In the northern half longitudinal uplifts produce long-crested ridges. The eruptive rocks, like those of the southern area, are younger than the enclosing strata. The dykes are innumerable; in one place a dyke was counted every fifty feet horizontal on a long spur.

The great masses of crystalline rock and the honey-combing of the soft strata by dykes has enabled this range to resist the erosion which has levelled the adjoining country and made it what Warren Upham calls a good example of "an eroded mountain range."—Bull. A. G. S., Vol. 3, 1892.

Geological Survey of New Jersey, 1891.—The work accomplished by the State Geologist and his assistants during the past year is reported by Mr. Smock as follows:

A study of the surface or pleistocene formations of the northern part of the State, by Prof. Salisbury; (2) an examination of the oak-land and pine-land belts of the State, by C. W. Coman; (3) a continued study of the water-supply and water-power, and (4) in co-operation with the United States Geological Survey, a study of the crystalline rocks of the highlands of northern New Jersey.

Some notes on the active iron mines and on artesian wells have been collected.

Numerous maps and charts accompany the report.

A Hyena and Other Carnivora from Texas.—At a meeting of the Philadelphia Academy Prof. Cope stated that he had during the past season while exploring the eastern front of the Staked Plains of Texas with the party of the Geological Survey of that State under Prof. W. F. Cummins, obtained the remains of some interesting carnivora from the Blanco or Pliocene beds. One of these is a hyena nearly allied to the genus Hyæna, and the first species of this family found in America. It, however, differs from the typical genus in having a fourth premolar in the lower jaw, and probably in having a shorter blade of the sectorial tooth in the upper. He proposed the name Borophagus for the genus, and for the species the name *diversidens*. The third lower premolar is very large and robust, greatly exceeding the fourth in dimensions. The latter is low and molariform; the inferior canine is large. The measurements are as follows: Transverse diameter of canine alveolus, 13 mm.; do. of posterior alveolus of pm.

iii, 13 mm.; diameters of pm. iv; longitudinal 4 mm.; anteroposterior, 10; transverse, 8. Diameters of pm. iii; longitudinal, 17 mm.; anteroposterior (partly restored), 28; transverse, 15. The species is as large as the spotted hyena, and was the scavenger of the Blanco Fauna.

Another interesting carnivore is a weasel of a new genus and species, which it was proposed to call *Canimartes cumminsii* after its discoverer. The genus *Canimartes* is allied to *Mustela*, differing only in the presence of two superior true molars. Metaconid of inferior sectorial well developed; talon of the same trenchant. The species is as large as the fisher.

A third carnivore is a cat, provisionally referred to the genus Felis under the name of *F. hillianus*, after Prof. Robert T. Hill, the well-known geologist. This cat is about the size of the cheetah, and has large canine teeth without grooves, and the feet are shorter than in modern cats.—E. D. Cope.

Geological News, General.—Mr. Hilgard's notes on the Cienegas of California show them to be of considerable economic importance. A cienega is a limited area showing a growth of water-loving plants, appearing sporadically in otherwise arid surroundings. Observation shows this area to be a débris fan or cone, having its apex near the mouth of a cañon. The débris consists of alternate deposits of rounded gravel and cobble, fine silt, and even clay. These deposits form a natural storage reservoir for the flood waters of the cañon, annually replenished, provided an open cobble surface is maintained at the apex of the cone. The conditions necessary for cienega formation are fulfilled in the granitic ranges of southern California.

Lee Lake, which furnishes the water supply of the "South Riverside" colony in the Valley of Temescal Creek is an exemplification of the value of the Cienega formations. This lake is fed entirely by an almost continual ooze from the masses of débris that have accumulated in front of the two uppermost cañons of the Temescal Valley.—Bull. Geol. Soc. Am., Vol. iii.

Archean.—The conclusions reached by Mr. N. H. Winchell in regard to the occurrence and distribution of the Mesabi iron ore of Minnesota are that no theory has yet been proposed that is satisfactory, and the one cause acting with sufficient force on a geographical area sufficiently wide to which appeal can be made for the geographic and stratigraphic distribution of this ore, is *oceanic sedimentation*.—

Am. Geol., Sept.. 1892.—Prof. F. W. Hutton is inclined to think that the Foliated rocks of Otago belong to the archean rather than the paleozoic era. The absence of plication and of cleavage oblique to the stratification throughout the district are sufficient proofs that the foliation is not due to crushing or dynamic metamorphism, while it cannot be considered as a region of contact metamorphism, for the only eruptive rocks are those near Queenstown, and they have been foliated along with the rest. The metamorphic action would, therefore, appear to be due to the internal heat of the earth at a very early period of its history, when the temperature gradient was much steeper than it is now.—Trans. New Zealand Inst., Vol. xxiv.

Paleozoic.—In his notes on the Devonian Fish-Fauna of Spitzbergen, Mr. A. Smith Woodward confirms the views published by Prof. Lankester that two distinct horizons—an upper and a lower—are recognizable in the Devonian formation of Spitzbergen.—*Ann. and Mag. Nat. Hist.*, 1891.——Mr. Walcott has obtained data which establish the fact that during the Middle Cambrian there was an immense deposition of sediments that now form a series of shales and limestones nearly 3000 feet in thickness. The fauna of Middle Cambrian time in Tennessee is essentially the same as that of the basal deposits about the Adirondack Mountains, the upper Mississippi Valley areas of Wisconsin and Minnesota, those about the Black Hills of Dakota, and the Llano Hills of Texas.—*Am. Jour. Science*, July, 1892.——Mr. C. A. White agrees with Mr. T. W. Stanton in his conclusion that the Bear River formation is not equivalent to the Laramie, but that it occupies a position beneath the greater part of the equivalent of the Colorado formation of the marine cretaceous series.—*Amer. Jour. Sci.*, Vol. xliii.——Paleontologists are indebted to W. H. Sherzer for a monograph of the genus Conophyllum. So vague have been the old definitions of the genus that in the ten species thus far assigned to Conophyllum there are at least five different genera represented.—Bull. G. S. Am., Vol. iii, 1892.

Mesozoic.—A Cretaceous Flora has been discovered in the Holma sandstone, southern part of Sweden. The fossils consist of silicified trunks in place, some small twigs and well preserved pine cones. Two of the species discovered are new, and have been named *Pinus nathorstii* and *Cedroxylon ryedalense*. Dr. Conwentz has fully described both their external characters and their internal structure in a paper recently published in Kongl. svenska Vetenskaps Akademiens.——Mr. Dumble includes under the name Reynosa a series of deposits

occurring in Western Texas and extending into Mexico. They overlie the Fayette sands and consist of gravel cemented by a very porous tufaceous limestone. In some places only the limestone is present. It contains such fossils as *Bulimus alternatus* Say, and seems to be in part the equivalent of the Equus beds of southwestern Texas described by Leidy and Cope.—Bull. Geol. Soc. Am., Vol. iii, pp. 219–230.——Part 4 of Contributions to Canadian Micro-Paleontology has been published by the Canadian Geological Survey. It consists of descriptions and illustrations of thirteen new and three previously known species of Radiolaria from the upper cretaceous rocks of northwestern Manitoba. The report was prepared by Dr. D. Rüst, of Hanover, Germany, who has made a life study of fossil Radiolaria.

Cenozoic.—A fine series of mandibles of *Phascolomys mitchelli* in the Queensland collection supports the view of Mr. DeVis that *P. mitchelli* and *P. platyrhinus* are distinct species. The same writer also affirms that *Sceparnodon* is not a synonym of *Phascolonus*, basing his assertion upon a study of the upper and lower incisors of *Sceparnodon*. —Proceeds. Linn. Soc. N. S. W., Vol. vi.——Mr. Lydekker has recently described and figured a Sirenian Jaw from the Oligocene of Italy. Some peculiarities of dentition appear to him to point clearly to an Artiodactyle ungulate ancestor with short crowned and selenodont molar teeth. This presumed origin has been urged by zoologists, but until now there has been no accepted proof of their derivation; nor is it likely that any such will ever be found.—Proceeds. London Zool. Soc., 1892.——The discovery in Queensland of a second species of Owenia establishes the validity of that genus. Mr. C. W. DeVis proposes, since the name *Owenia* is preoccupied, to substitute for it the name Euowenia.—Proceeds. Linn. Soc., N. S. W., Vol. vi.——According to Lydekker *Viverra hastingsiæ*, described by Mr. Wm. Davies, from the upper eocene of Hordwell, is specifically inseparable from *V. angustidens*.—Quar. Jour. Geol. Soc., Aug., 1892.

BOTANY.

Development of the Floral Organs in Aster and Solidago.—The point of growth of the shoot axis becomes very much retarded, and as a result the growing point is transformed into a broad, somewhat elevated disc on which are to appear flowering capitula with centrifugal inflorescence.

The first structure indicating an individual embryonic flower on the receptacle is a hemispherical outgrowth almost perfect in outline and becoming obconical as growth takes place. This embryonic tissue standing on a lateral axis, constitutes the foundation from which arises a differentiation of tissue into special organs. Thus far the path of embryonic development remains the same for all organs, even those of the most various kind. So we have the law of greater structural similarity well worked out in the earlier stages of organisms. From this condition of things on, a new departure is made; the apex of the broad flower axis ceases to grow, while the peripheral portion continues to develop; here we have the first hint of the initial growth of true floral organs. A tubular ring is thus formed and on its peripheral wall small papillæ rapidly arise, giving the structure a cup-shaped appearance with a shallow depression and scalloped margin. This so-called cup elongates, its sinus grows deeper, and the five corolla lobes become sharply defined and are known at once by their shape. Simultaneously with the development of the floral organs in the rising ring, in which there is a complete fusion of all flower parts until liberated, a deep central depression is forming, when ultimately the ovule-bearing portion is placed beneath the rest of the flower parts. Thus we have an epigynous flower with an inferior ovary. However, there are some who would substitute the word hypogynous for epigynous, basing their argument on the theory that all the floral organs, in their initial state, are coalesced in the annular wall; that the appearance of each is due to the liberation of their uppermost parts; that each whorl may appear either in acropetal, or certain whorls, seemingly basipetal, order. The real origin and behavior of the floral organs in their younger stages of development as correlated with the inferior ovary has attracted but little attention, and, therefore, no definite statement can be made as to the true relationship existing between the floral organs in their embryonic condition.

Turning now to the order of development of flower parts, the first foliar structure that appears is a petal. At first they appear as small papillae on the annular wall. In their further development the tissue thickens and the epidermal cells with their rather heavy cell walls become quite large; in later growth their tissue becomes more uniform, and the tips of the five marginal teeth of the corolla-tube turn inward, thus furnishing an excellent protection to the andrœcium and gynœcium. The petals forming the flower tube are not simply contiguous but united, and as the tube elongates it assumes, slightly, the form of a funnel whose upper margin has five spreading teeth. The tubular corolla is not composed of parts originally separate and subsequently united by their lateral margins, for the parts set free are the marginal teeth arising from a common basal tissue; and this tissue develops and elongates *pari passu* with the growth of the nascent organs within.

Almost immediately following the visible corolla, appearing on its inner basal margin, are five minute elevations, the rudimentary stamens. These develop with remarkable rapidity, and their primitive, oval form is soon exchanged for one that is oblong. The histological constituent of the stamen in its early growth is a mass of uniform parenchyma. Presently a new condition arises; a differentiation of tissue into anther lobes and a connective takes place. The fibro-vascular bundle, which is a continuation of that of the flower-axis, though very much reduced, differentiates in the upper part of the stamen, and forms the so-called connective. At the same time there is a modification of tissue which develops into anther lobes; these are connected and yet separated by the connective. In the early process of growth there appear two longitudinal ridges on each half-anther lobe; these answer to the future pollen sacs, and give rise to the archesporium cells, which, usually having but one row in each pollen-sac, again give rise to the squarish mother-cells; in turn the latter yield four pollen grains each. The developmental path, pursued by all pollen grains, is so common that space is of more avail than their further treatment. To give a more complete account of staminеal tissue, mention also should be made of the anther tube. At first the filament develops slowly and the stamens are distinct from one another, but just preceding the unfolding of the flower bud the filament gains length at a very rapid rate by the elongation of its cells; finally the lateral edges of the anthers become coalescent, thus forming a tube, which, when the flower is fully developed, projects beyond the tubular corolla. The anthers do not simply cohere, but unite, for cross sec-

tions show the blending of epidermal tissue; this makes the union complete.

Simultaneously with the origin and development of the stamen, another structure comes into view—the calyx. When first observed there is a bulging out of the epidermal layer in the region of the seeming insertion of the other floral parts. The tube of this outgrowth is not distinguishable from the ovarian wall, but its limb is visible as a tuft of hairs. Primitively, it consists of a short, delicate bunch of hairs, arranged in a circle at the upper extremity of the young ovary. Later, the hairs by rapid growth develop into long appendages, made up of several rows of narrow but extremely elongated cells, the lower ends of which splice into the upper ends of the cells below at the point where the upper end of the cells below turn away from the main trunk, and rapidly taper into an acuminate tip; hence the hair has the appearance of a barbed spear. By its late appearance in development and its epidermal structure some do not regard the pappus as a calyx, while on the other hand others consider it so, though very much reduced in form and structure, the result of the pressure of surrounding bodies.

A little previous to the formation of the pistil another structure may be seen to arise from the receptacle between the individual florets. These foliar bodies, or bracteoles, very much resemble the scale-like leaves of poorly developed vegetative branches. They project quite far between the individual florets; their epidermal tissue consists of very thick-walled, elongated cells surrounding several layers of smaller parenchyma cells.

The next and last of the floral organs to appear is the pistil. About the time when the stamens begin to assume an oval outline and form a constriction near their bases, thereby separating the stamineal tissue into anther and filament, there is detected, on the inner border of the primitive ring in the region of stamineal insertion, an inward growth of cells. This cell tissue gradually develops inward around a common axis until all sides meet, and at the same time elongates in the direction of the flower axis, thus forming the style above and completely overarching the once oval cavity below, changing it to a flask-shaped cavity which is the true ovarian cell. Just at this stage of development it may be mentioned that from now on, the flower parts develop with remarkable rapidity, and finally the flower axis is very much elongated, the gynœcium forming the terminal structure of the flower. The growth of the pistil is somewhat analogous to that of the stamen. As before stated, stamineal growth is partially retarded up to a certain

point, from whence it makes rapid strides by the elongation of the cells of the filament; and for a time the stamen crowns the summit of the flower. So there is a similar phase of growth which characterizes the style; there is a slight cessation of its growth until the anthers begin to shed their pollen, when the style by rapid development pushes its way up through the syngenesious stamens. The lengthening of the style is due to the growth and elongation of the carpellary cells above the ovary. In this case is found a good example of proterandry, which indicates cross-pollination. After the opening of the flower the style lengthens and the pollen is pushed out of the anther tube by the brush-like upper portion of the style as the anthers dehisce. The lines of the stigmatic receptive surface remain intact until that portion of the two branched style is shoved above the anther tube, whence the two branches separate, curving far back and exposing the stigmatic papillæ on their inner faces; thus the style is made the instrument for disseminating the pollen which it cannot use for itself; as a result, cross-pollination, with almost absolute certainty, is insured.

To speak further of the two-branched style: Two kinds of hairs are detected, viz., stigmatic papillæ and brush hairs. The former are usually short, being either acutely or obtusely tipped, and are confined to the inner faces of the style branches, while the latter are cylindrical, epidermal outgrowths, having various arrangements both on the inner and outer faces of the style-branches. In Aster the style-branches are flattened and linear from their bases to the ends of the two lines of papillæ which line each stigmatic surface. Above the termination of the stigmatic lines are seen brush-hairs which cover both faces of the style-branch. In Solidago the style-branches resemble very much in outline those of Aster. Two stigmatic lines are observed which extend from the base of the branch to a point about one-half the distance to its tip. The brush hairs usually cover the whole outer surface of the branch, and the edges and tip of the inner face above the termination of the stigmatic lines.

It yet remains to speak of the tissue and its modifications that make up the structure of the style. It consists chiefly of ordinary parenchyma, the central portion of which is modified parenchyma, while the upper stigmatic portion is a differentiation of the epidermis into a soft mucilaginous tissue, thus forming a loose conducting mass for the penetration of the pollen tube. In the center of the conducting tissue is also seen a very narrow tubular opening, indicating that it is a continuation of the ovarian cavity. This seems to be constant throughout the species examined. Before concluding, however, the description of

the different floral organs, let the following order of succession as observed in their sequence of development be noted, viz.: corolla, calyx, androœcium and gynœcium, although this order of parts does not correspond to Goebel's generalizations on Compositæ. There may be evidences showing a disturbance in the acropetal order of development of whorls, but of necessity the calyx is developed first, and its late appearance, without doubt, is due to the late setting free of its upper portion.

Simultaneously with the development of the ovule appear small, fleshy glands above the ovary at the base of the style; these form a disc, and are supposed to represent an inner row of imperfectly formed stamens.—GEORGE W. MARTIN (in 'The Development of Flower and Embryo-sac in Aster and Solidago").

ZOOLOGY.

On Nectonema agile Verrill.[1]—WARD, H. B.—Dr. Ward's paper upon this curious nematode has been awaited with considerable interest by all who heard his preliminary paper given before the Society of American Morphologists last winter, and, in justice to Dr. Ward and Prof. Mark, in whose laboratory the work was done, it must be said the paper is up to our expectations. Many curious thread-worms have been described heretofore, but helminthologists have generally been able to give homologies in other species for all the organs mentioned. Verrill's curious *Nectonema*, however, is a worm which possesses certain structures which are totally foreign to other nematodes.

According to Ward, *Nectonema* is a long (50–200 mm.), slender and exceedingly active round worm, found swimming at the surface of the sea with a rapid, undulatory motion. The anterior portion of the body is semi-transparent, and internally an anterior chamber is divided from the general body cavity by a partition which is concave anteriorly. This anterior chamber, together with its contents, is the most interesting part of the animal in question, for it is a structure which we cannot at present homologize with any organ of other nematodes. It is traversed by the rudimentary œsophagus, and contains ventrally the brain, while the dorsal space is occupied by four large conical cells which send processes down into the nervous matter of the brain. These cells are looked upon by Brüger as gland cells, but Ward supports the view that they are ganglion cells, which were situated on the surface of the brain, have become enormously large, and have extended up above the brain into the lumen of the anterior chamber. At first thought this supposition would seem rather far fetched, but, curiously enough, Ward has shown that there are in the brain five pairs of large ganglion cells which are quite constant in their position and which resemble these two pairs of dorsal cells in certain respects; *the fifth pair of cells is only half in the brain and half projecting above it, thus apparently forming the first stage in the migration which the dorsal cells have already accomplished.*

The digestive tract is quite rudimentary, and, as Ward states, points directly to the view that *Nectonema* is, in all probability, a parasite during the earlier part of its life.

[1] Bulletin Mus. Comp. Anat., Cambridge. 1892. Vol. xxiii, p. 135–188, with 8 plates.

In regard to the position of this worm in the classification, Ward believes that it is more closely allied to *Gordius* than to any other known nematode. The general structure, the ventral nerve cord, the anal ganglion, the absence of lateral lines, and the dorsal position of the sexual organs, together with the terminal openings of the same, all tend to support this view.

For other interesting details in regard to *Nectonema*, we must refer to the original article. At the same time we wish to call attention to the American *Gordiidæ* and Mermithidæ which would afford a most interesting and valuable field for scientific work. They should be worked up from the systematic, embryological and anatomical standpoints, and the reviewer thinks, judging from the admirable way in which Dr. Ward has studied this closely allied form *Nectonema*, that Ward is in an especially good position to revise these twò families. Reviewer would hence take the liberty of suggesting the revision to Dr. Ward as a field for future investigation.—C. W. S.

Linton on Entozoa.[2]—Dr. Linton has recently published the results of his studies on the following parasites of birds:

1. *Filaria serrata* sp. n. is described from the intestine of *Circus cyaneus hudsonius*. The description is based upon a single male specimen, and is very incomplete. In the figures of the head two slings are drawn, which, if the drawing is correct, would probably place the species in the genus Dispharagus. But as Linton does not make any statements in regard to the œsophagus, the original material must be re-examined to determine this point.

2. *Ascaris spiculigera* R. was found in *Pelecanus erythrorhynchus*.

3. *Echinorhynchus rectus* sp. n. is described from *Larus sp.*

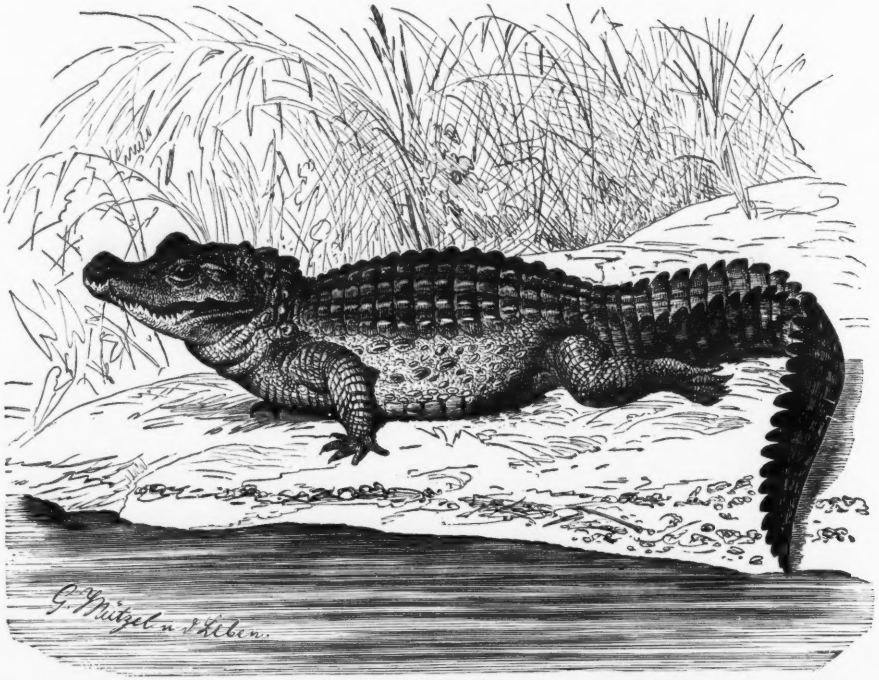
4. *E. striatus* Goeze was found in the intestine of *Oedemia americana*.

5. *Holostomum variabile* Nitzsch, found in several species of birds.

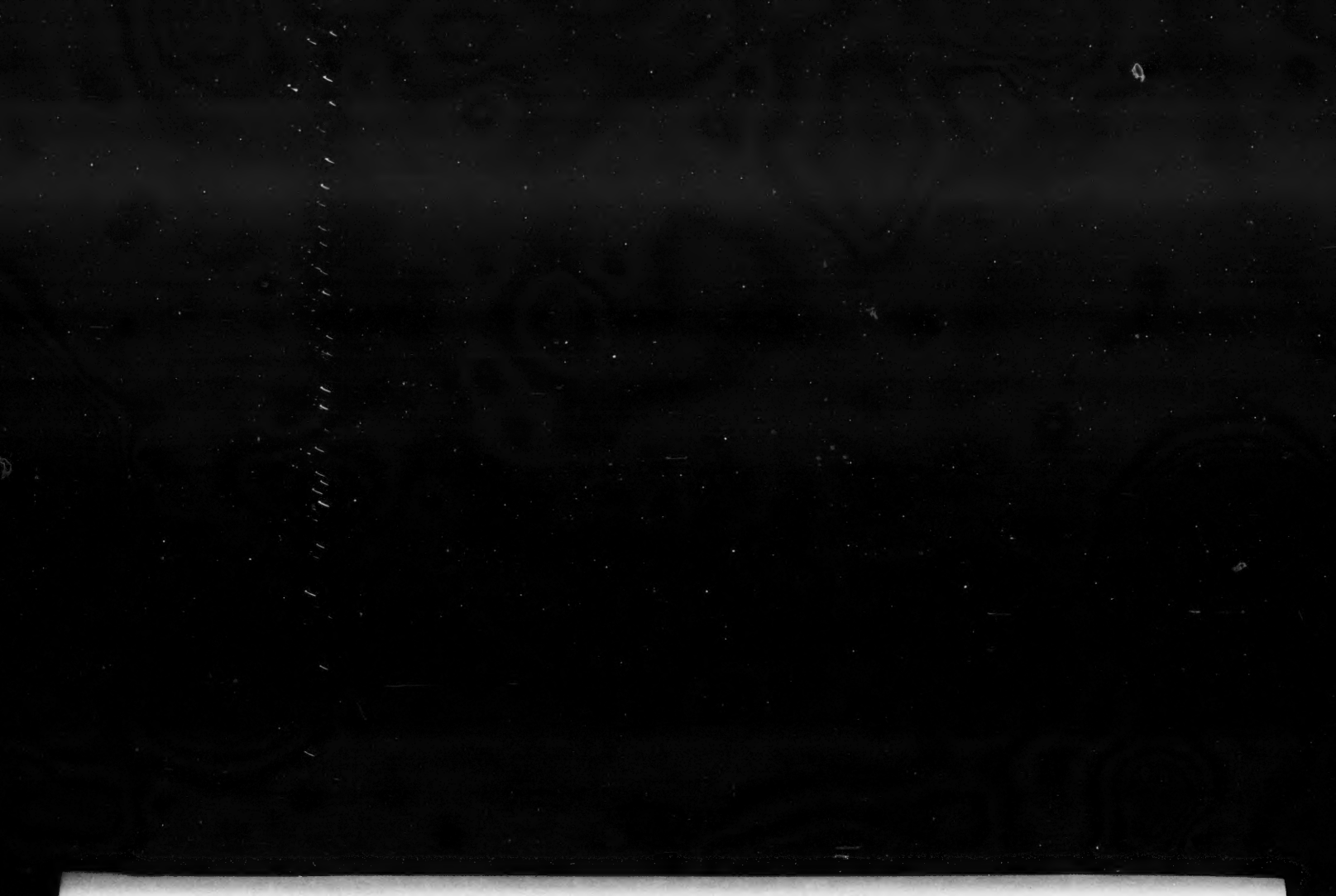
6. *Distomum* (?) *verrucosum* sp. n. Under this name the author describes a fluke found in the intestine of *Larus californicus*. As basis for the description, Linton had one entire specimen and a fragment of a second specimen. Unfortunately, he has made the mistake to start with, of choosing a specific name which has already been applied to three other species of the same genus (*D. verrucosum* Molin, from *Labrax lupus; D. verrucosum* Poirier, from *Thynnus vulgaris*, and *D. verrucosum* Busch, from *Ophidium barbatum*). Von Linstow gives these three in his Nachtrag (Compendium der Helminthologie,) as different species. I have not the articles at hand at present, so cannot state

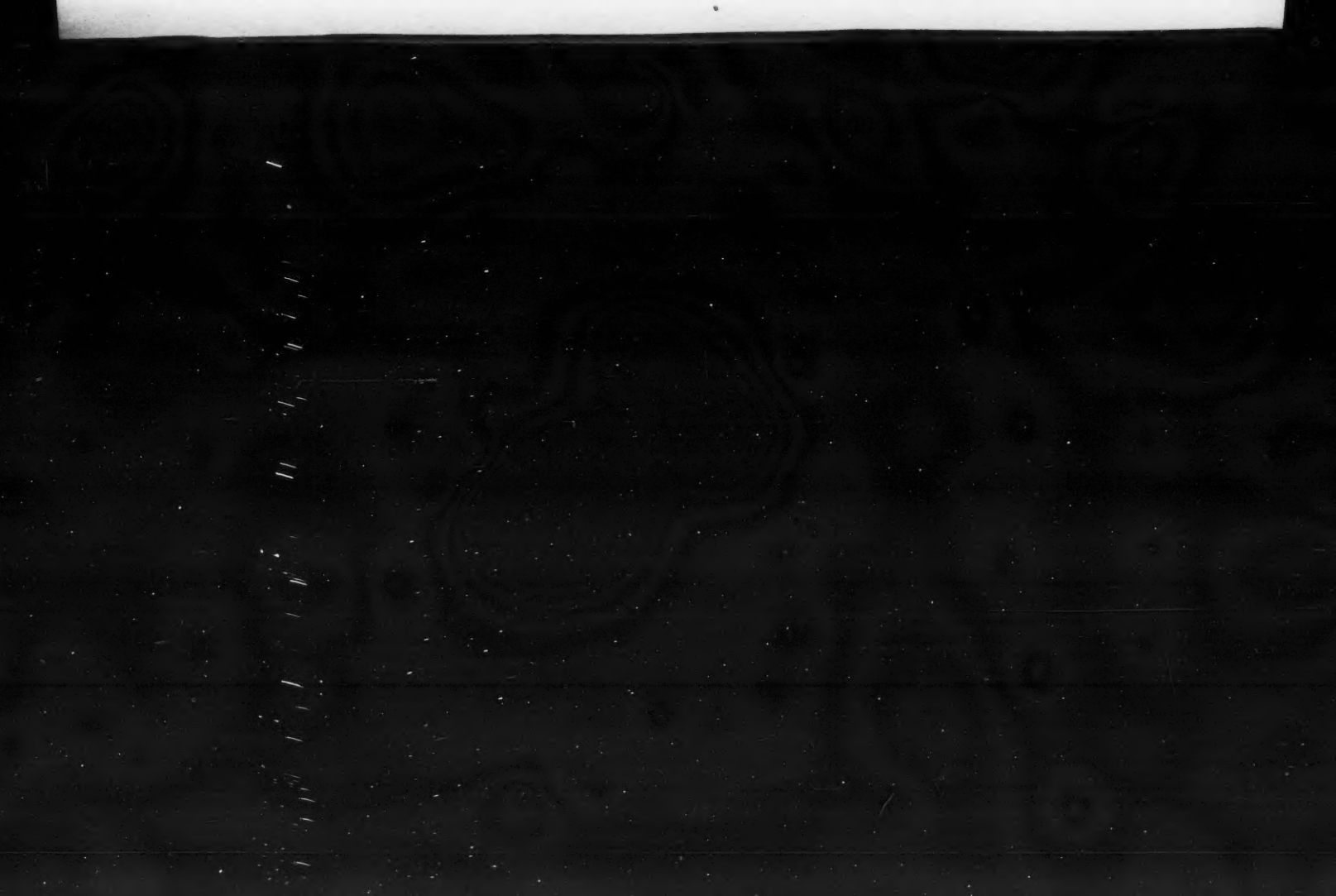
[2] Notes on Avian Entozoa (Proc. U. S. Nat. Mus., Vol. xi, pp. 87–113, Pls. iv–vii.)

PLATE XXX.



Osteolaemus tetraspes. The African Alligator Crocodile.





whether any two of them are identical with each other or similar to Linton's species. At any rate, the name is clearly preoccupied, and it is inconceivable how Linton could give the same name to a fourth species which he describes as new.

7. *Distomum flexum* sp. n. from *Oedemia americana.*

8. *Dibothrium cordiceps* Leidy. *Larus californicus* as a new host.

9. *D. exile* sp. n., from *L. californicus.*

EPISION gen. nov. Diagnosis: "Anterior end of body (head) lamellate, more or less crispate, deflected. Body proper, tæniæ form, segmented, segments not distinct. Reproductive apertures lateral (?)."

Epision is, without doubt, identical with *Tænia malleus* Goeze, 1782. Since Goeze's time, the parasite has been mentioned by Zeder, 1800; Frölich, 1802; Rudolphi, 1808, 1810, and 1819; Bremser, 1824; Creplin, 1839; Dujardin, 1845; Schlotthauber, 1860; Krabbe, 1869; Krefft, 1871. It has been figured by four of these authors.

10. *E. plicatus* sp. n., from *Oedemia americana.*

11. *Tænia* sp. fragments from *Larus* sp. and *Colymbus* sp.

12. *Tænia porosa* R. from *L. californicus.*

13. *T. filum* Goeze, from *L. californicus.*

14. *T. macrocantha* sp. n., from *Oe. americana.*

15. *T. compressa* sp. n., from *Fuligula vallisneria.*

It must be confessed that Linton's paper is a disappointment, and far inferior to his papers on the parasites of fish. Although he has given good descriptions of the external appearance of the parasites, measurements, etc., yet he has said almost nothing about the internal organs. In fact, he has described as a new species of *Dibothrium*, a form in which no genital organs were developed; while in his supposed new genus he cannot even give the position of the genital pores with certainty, and tells us practically nothing in regard to the genital glands. In the case of *T. filum*, *T. macrocantha* and *T. compressa*, an attempt is made to figure the genital organs, but the figures are very poor, too small and do not contain enough detail. We are told nothing of the number of testicles or of the topographical relations of the various organs.

The time has now passed when an helminthologist is justified in creating new species or new genera of tape-worms on external form alone, especially when only one or two specimens are at his disposal. If specimens of Linton's species were sent to me for determination, and I knew the hosts from which they came, I might be able to determine the various forms; but I must confess that if the parasites alone were sent, with no statement as to where they came from, it would be practically impossible to recognize the species. Even with the forms

with which I am best acquainted, i. e., with the parasites of man and the domestic animals, I rarely trust myself to diagnose a tape-worm without first examining the anatomy of the segment, for I have found that after examining no less than 1200 tape-worms of cattle and sheep, it is the easiest thing in the world to make mistakes such as diagnosing a *Moniezia planissima* as *M. expansa* or as some other species. The helminthologists all over the world have now recognized the uncertainty of external form, in determining Cestodes and Trematodes, and are revising the orders with reference to their anatomy; and with this movement in full force, I cannot understand how such an exact observer as Linton now allows himself to publish new species based on the external appearance of one or two specimens. It must, of course, be admitted that he could probably recognize the species again, since he has studied the type, but he should remember that his colleagues cannot obtain the same impressions from any description, no matter how good it may be, which he obtains from seeing and studying the original animals.

It is to be hoped that our friend, Dr. Linton, will obtain more material of the species he has described, and that he will favor us with exact accounts of their internal topographical anatomy.

—C. W. STILES.

Systematic Arrangement of the Families of Birds.[3]—Prof. Max Fürbringer calls attention to Dr. L. Stejneger's systematic arrangement of the families of birds as adopted in the *Standard Natural History*. Although Fürbringer differs in his ideas from Stejneger, he expresses his "volle Bewunderung" at the latter's system, and continues, "Es ist die ernste That eines hervorragenden, in seiner Methodik auf den rechten Bahnen wandelnden Forschers and Denkers und verdient als solche den besten neueren Vogelsystemen gleich gestellt zu werden."

Shufeldt on the Anatomy of the Humming-Birds and Swifts.—In his review of my popular monograph of the humming-birds, in the October NATURALIST, Dr. Shufeldt declares my description of the humming-bird's tongue to be erroneous, and "kindly invites" my attention "to the very careful dissections made by the Scotch anatomist, W. MacGillivray," and also his own "extensive dissections," the results of which were published in *Forest and Stream* for July 14, 1887, p. 581. The inference clearly is that Dr. Shufeldt would have me appear ignorant of both these treatises, though he should know that I am

[3] Journal für Ornithologie, April, 1892.

quite as familiar with them as he is himself. The facts of the case are that my purposely brief description, which Dr. Shufeldt criticizes so harshly and unnecessarily, is substantially a condensation of MacGillivray's—my knowledge of the subject being based chiefly on the latter and Mr. F. A. Lucas' later dissections of thirteen species[4] (instead of one, as in the case of Dr. Shufeldt's "extensive dissections").

Dr. Shufeldt's peculiar notion that the swifts are more nearly related to the swallows than to the humming-birds, first set forth by him in 1883, was so thoroughly "exploded" by his reviewers[5] that his resurrection of so dead an issue surprises me. Apparently he is not familiar with the literature of the subject, for, if he were posted, he would know that leading authorities on avian comparative anatomy are overwhelmingly if not unanimously against his side of the question. I would therefore suggest that he consult Fürbringer, Parker, Garrod and Gadow, and thus discover how much he has to learn regarding the matter which he handles with so much assurance. Even a careful perusal of Huxley (whom, by some strange hallucination, he imagines his abettor) may also prove instructive to him.—ROBERT RIDGWAY.

[4] Cf. Proceedings U. S. Nat. Mus. Vol. xiv., No. 848, pp. 169–172, pl. iv.

[5] Cf. Stejneger, *The Auk.*, July, 1886, pp- 404–406, and Lucas, *The Auk.*, October, 1886, pp. 444–451.

EMBRYOLOGY.[1]

Entwicklungsmechanisches.—Awaiting the publication in the Zeit. f. Wiss. Zool. of a fully illustrated account of his exceedingly important work upon the value of cells in cleaving eggs, Hans Driesch[2] puts forth a short preliminary notice of results recently obtained at Naples.

Having previously shown[3] that one of the first two cleavage cells in an echinoderm could, by itself, form a complete larva, the author now wishes to combat the view that any real process of regeneration here leads to the formation of the symmetrical whole animal from the half ovum. This idea of a regenerative process has just been maintained by Chun in a paper presented to the *Deutsche Zool. Gesellschaft*, and very briefly noticed in the *Zool. Anz.*, xv, June, 1892, p. 225. Chun separated the first two cleavage cells of the Ctenophore *Bolina*, and found each could produce a half-animal that later became a complete one by regeneration. This process was seen also in many eggs not artificially interfered with.

Hans Driesch removes one of the first four cleavage cells of a sea-urchin and finds the remaining three cleave as if the fourth were still present, yet later a normal, but smaller, blastula (and in more than twenty cases a normal pluteus) is formed. One of the four cells may also, in some cases, give rise to a normal but very small pluteus.

Thus we may take almost any fraction of the cleavage material and, if it is not *too* small, obtain an animal differing from the normal only in size.

The author maintains that there is no re-formation of the removed cleavage material, but the amount present closes in to form a small blastula. There is no regeneration.

In these facts is also seen the fundamental identity of the cleavage cells, their lack of preordination. To emphasize this conception of the value of cleavage cells the author communicates the results of experiments the details of which we hope will soon be made known in his complete demonstration. In the egg of the sea-urchin the first three spindles lie in an equatorial plane, then the next four in a verti-

[1] This department is edited by Dr. E. A. Andrews, Baltimore, Md.

[2] Anatomischer Anzeiger, vii, Aug., 1892.

[3] See AMERICAN NATURALIST, Feb., 1892, p. 178.

cal plane (whence the eight cells, four above and four below, result). Now by the application of pressure it is possible to force all these spindles to lie in one plane, whence there results a plate or single layer of eight cells. These cells may remain in this abnormal position and divide vertically so that there are two layers of eight or in all sixteen cells, which subsequently divide tangentially. A little consideration will convince one that here cells, or nuclei, normally forming part of only one pole, give rise to parts of both poles. Since these confused cleavage cells may proceed to form normal plutei their indifferent, omnipotent character cannot be disputed.

These and other experiments, not here revealed, lead Hans Driesch to the following conceptions of the value of cleavage: (1) Cleavage forms a homogenous, indifferent material any portion of which, almost, may form a complete organism when isolated or any part of an organism when united with other portions. (2) The embryo acquires form through unknown laws of correlation; it is not a mosaic as Roux has maintained.

Budding in Hydroids.[1]—Contrary to the usually received conception, Mr. Albert Lang, working with Prof. Weismann, contends that in hydroids buds are formed not by equal outgrowth of both ectoderm and entoderm, but primarily by the growth of the ectoderm alone, this germ layer early giving rise to a new entoderm for the bud.

In an introductory note Prof. Weismann relates that purely theoretical reasons, the probability that "bud idioplasm" is confined to certain cells of the ectoderm, led him to doubt the participation of the entoderm in the formation of hydroid buds.

The body of the paper is devoted to a description of sections made through *very early* stages in the budding of *Eudendrium racemosum*, *E. ramosum*, *Plumularia echinulata*, and *Hydra grisea*, preserved for the most part with the aid of corrosive sublimate.

Although in the stages usually examined the ectoderm and entoderm of the bud are continuous with those layers in the adult and surround a prolongation of the gastric cavity of the adult, yet the study of very early stages shows that this continuity does not arise by mere proliferation in each layer. At first there is a thickening of the ectoderm over the area that is to give rise to the bud; here the basement membrane appears to be dissolved; is at all events absent; thus ectoderm and entoderm are here continuous with one another; rapid cell division takes place in the ectoderm, while the entoderm seems to remain

[1]Zeit. f. Wiss. Zool., 54, July, 1892, pp. 365–383.

passive, or after a time is even cast off or degenerates; certain small ectoderm cells *appear* to migrate into the entoderm and are interpreted by Mr. Lang as there giving rise to a new entoderm. While a new basement membrane is soon formed over most of the budding area it remains indistinct or absent around the periphery; a solid outgrowth is thus formed, within which a cavity appears by the separation or rearrangement of the new entoderm and loss of the old; we thus arrive at the two-layered, hollow outgrowth commonly regarded as the earliest stage in the formation of the bud.

Unfortunately the illustrations given by the author are not numerous enough to convey to the reader the same convictions that the study of series of sections might. The equally important and difficult questions, the migration of ectoderm cells and their conversion into new entoderm seem to require a reinvestigation of the subject before we can be fully convinced that the ectoderm is really the only seat of proliferation in budding hydroids.

Comparing this bud formation with embryonic processes, the author points out the close parallelism between the formation of new entoderm by multipolar migration from the ectoderm of the bud and the formation of the entoderm of the embryo by migration of ectoderm cells of the blastula.

Instead of regarding the process of budding in coelenterates as a modified fission of the adult we may refer it back to the blastula stage and explain it as acquired in some ancestral blastula form, as an atavistic representation of a non-sexual mode of reproduction in a blastula-like coelenterate ancestor.

Similarly Seeliger has interpreted budding in Bryozoa as due to a process of twin-formation in the embryo.

Budding in annelids, tape-worms and scyphistomas, where all germ layers are concerned, may still be regarded as having arisen from regenerative processes. Budding in Salpa remains unexplained.

Notes on Elasmobranch Development.[5]—Prof. Adam Sedgwick brings forward some new facts and considerations tending to support his theory of the origin of metamerism in animals and also making clearer his views upon many important questions illustrated by his observations upon the embryos of Scyllium and Raia.

The blastopore of elasmobranchs, immediately before it closes, is an elongated, narrow slit, slightly dilated in front, where it lies on the floor of the medullary canal, and more dilated behind (Balfour's yolk-

[5]Quart. Jour. Mic. Sci., June, 1892.

blastopore). Between these two limits it takes the course of a reversed letter S. The anterior part perforates the medullary canal and is dorsal; this is continuous round the end of the tail with a ventral part, which extends forward along the ventral side of the tail as far as the yolk-stalk. Along this it passes to continue backward along the yolk as the slit-like, non-embryonic part of the blastopore, which passes behind into the more dilated and posterior part of the so-called yolk-blastopore. In the author's view the blastoderm grows uniformly over the yolk at all points of its circumference. The notch of the embryonic rim represents the anterior end of the blastopore and the blastopore does at one time or another perforate the whole length of the medullary plate; anteriorly it keeps closing up as the embryonic rim grows backwards, so that it is never present in this region as more than a notch. Yet there is no "concrescence"—"to talk about concrescence and fusion of two halves is merely obscuring the real question and seeking to explain a process of growth by a phrase which has no satisfactory meaning."

The anus is formed within the area of the blastopore; is actually a part of the blastopore in some vertebrates; not so the mouth.

In *Scyllium canicula* the mouth is at first a longitudinal row of dots between the mandibular arches. These pores become connected to form a longitudinal slit extending forward into the rudiment of the pituitary body. Later the mouth shortens and widens to the adult form. Its slit-like form may be favorable to the view that it is derived from the anterior part of the blastopore, "though I admit that this does not constitute a very powerful argument."

The mandibular, hyoid and branchial arches are very much bent backward, which suggests that there has been not only a cranial but a cephalic flexure affecting brain, notochord and arches as well. Before such a flexure the mouth was a vertical slit looking forward or even extending onto the dorsal surface.

Regarding the metamerism of the head the author thinks that the number of primitive somites in any region of the head differs in closely allied genera. Hence the adult segmentation, constant throughout the vertebrates, has little value in determining the primitive metamerism. "We may, I think, even go farther and say that the adult arrangement of nerves and branchial arches, etc., characteristic of the vertebrate head, must have arisen subsequently to the disappearance of the primitive segmentation." The first or premandibular somite of Balfour, arising from a mass at first connected with the ectoderm, with the notochord and with the anterior end of the gut, thus presents

some resemblance to the primitive streak of the Amniota, and appears to contribute as a growing point to the anterior end much as the primitive streak does to the posterior end of the embryo.

Turning now to quite a different subject, the author affirms that in all the vertebrate embryos he has examined there is a protoplasmic continuity between the different layers and organs. "The cells of the young embryo, subsequent to cleavage, are connected by delicate processes. There can be no reasonable doubt that it (the network of such processes) is derived from the processes and strands left between the cells as a result of the incomplete cleavage of the ovum." Awaiting an investigation of this subject, which the author hopes to treat of in a future paper, he yet thinks "that there is, in my opinion, evidence to show that the whole of the nervous connections (by nerve-fibres and otherwise), both in the central organ and at the periphery, are developments of this pre-existing network, which connects together at all times the whole of the cells derived from the fertilized ovum."

Embryology of a Nematode.—A welcome addition to the scant literature of this subject has been made by Benno Wandolleck.[6] He studied fresh and preserved material of *Strongylus paradoxus*, devising some new and interesting methods.

Peculiar changes in the arrangement of yolk-spherules precede cleavage; the first plane is meridional and the cell at the animal pole, where the polar bodies were formed, has no coarse yolk, while the cell at the other end of the elongated egg is completely full of it. The clear cell gives rise to all the ectoderm, and at first is where the anterior end of the animal will be; the granular cell gives rise to the entoderm and the mesoderm, and is at first where the tail of the animal will be. The two cells rearrange themselves so that the ectoblast cell lies partly dorsal and the mes-entoblast cell partly ventral.

Subsequent divisions result in a solid mass of cells in which the more numerous, smaller ectoblast elements form a dorsal cap over the few granular, larger mes-entoblast cells. As an epibolic gastrula begins to form, a pair of mes-entoblasts become recognizable as the primary mesoblasts, whence arise two simple rows of mesoblast cells, one on each side. These two longitudinal mesoblast rows run parallel with the edges of the blastopore slit formed by the overgrowing ectoblast. This blastopore closes completely the anterior part last; at that point the mouth subsequently forms by a new invagination. The entoblast is now only two rows of few, large cells; these subsequently

[6] Archiv. f. Naturg, 58, 1892, pp. 123–147, plate IX.

separate from one another, after their number is increased, to leave the lumen of the digestive tract. Only short stomodeal and anal invaginations arise from the ectoblast.

As the mouth forms, ectoblastic cells around it sink in to form the nervous system. The reproductive organs are recognizable before this, as two large cells, one in each of the rows of only five or six mesoblast cells.

In the main the paper confirms the observations of Götte upon Rhabditis.

Note on an Abnormal Polygordius Larva.—Since reading Mr. E. A. Andrews' article on Bifurcated Annelids in the September number of this journal, it has seemed to me that some notes and sketches which I made during the summer of 1890 while enjoying the privileges of Mr. Agassiz's laboratory at Newport, R. I., are of sufficient interest to warrant their being published. They relate to a case of a peculiar bud formation in Polygordius. The larvæ of this annelid were very abundant for several weeks both before and after the dates here mentioned, and after this abnormal individual was observed all the tow that was brought into the laboratory was carefully examined for similar specimens, but none were found.

Figure 1 represents the larva as it appeared when first seen on August 9. The body was about equal in length to the longest axis of the head. So far as could be seen the head differed in no respect from that of the normal larva.

The bud was situated on the dorsal side of the body close behind the head, and was about equal to the body in both length and diameter, though as shown by the figures it was quite markedly club-shaped, the larger end being distally directed. The outer layer of the bud was distinctly continuous with the corresponding layer of the body, though neither at this nor at any later stage did it show anything of the superficial ring-structure or of the pigment spots, such as were seen in the body. I could not make out precisely the relation of the digestive tract to the bud, though its wall seemed to be folded somewhat in this region, the fold being capable of being thrust into the bud for a short distance.

A mass or thick strand of tissue could be seen within the bud, extending from near its base out to its tip, there to become fused to the inner surface of the distal wall of the bud. This strand was clearly separated all around from the external wall of the bud by an empty

space of considerable size, but I could not make out that the strand itself contained a lumen.

Neither at this nor at any later time did the digestion tube extend into the body behind the bud excepting as a mere diverticulum, though there seemed to be a body cavity in this region—more distinctly seen, however, at later stages.

A ciliated band was not present at this time, either at the posterior end of the body or at the tip of the bud, though in each place a circle of pigment spots was to be seen.

On the morning of August 11, forty-eight hours after the first sketch, shown in Figure 1, was made, the one shown in Figure 2 was drawn.

Both body and bud had increased in length considerably, but the former more, proportionally, than the latter. The digestive tube could now be distinctly seen to extend for a considerable distance into the bud, though it was constantly being thrust in for a greater or less distance and again withdrawn. There was a sort of fold just at the entrance that was continually changing its shape and position, by reason of which it was impossible to determine exactly what was the relation of the intestinal wall to the body wall.

The strand of tissue in the bud mentioned as being present in the preceding stage, has practically the same appearance and relations now, excepting that it was proportionally shorter.

The body cavity behind the bud was now quite distinct, and there was a circle of cilia around the body near its posterior end, but none on the bud. At this time the bud could be seen to contract somewhat.

While this sketch was being made the cilia of both the head and the posterior end of the body, together with some of the pigment spots of the head band were suddenly thrown off, and the animal sank to the bottom of the dish and became quiet, whereas it had before this time been swimming rapidly about.

Twenty-four hours later the sketch was made which is represented in Figure 3. The head was now much reduced in size, and the body correspondingly increased in length. The bud had also increased in length somewhat, but much less proportionally than the body.

The most interesting new feature observed at this time was that there was a communication between the digestive tube and the outside world through the bud, the anal opening being situated at the tip of the latter. Conclusive proof of this was furnished by the fact that a mass of fecal matter was seen to pass from the intestine into the bud and then out into the surrounding water. But still I could not be sure as to the real relation of the digestive tube to the external layer

of the bud. The fold mentioned in the preceding stage (*a* in Figure 3) was very distinct here, but was not usually in the position shown in the figure, i. e., projecting into the digestive tube, but was most of the

FIG. 1.

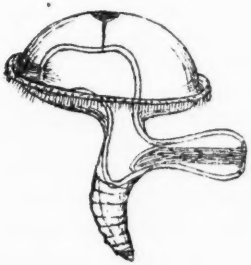


FIG. 2.

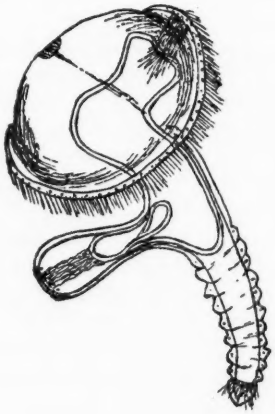
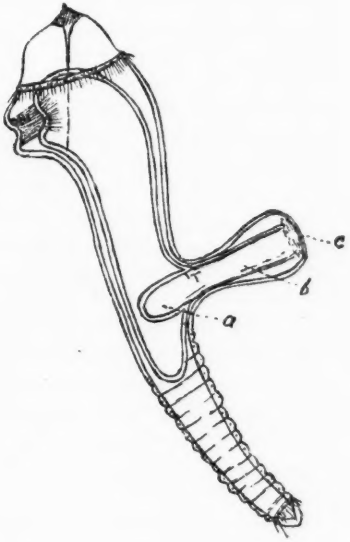


FIG. 3.



time thrust far into the bud, and it is certain that the fecal matter just spoken of passed *through* this. It is my belief from all that I could make out, that the strand of tissue described in the former stages now

contained a wide lumen throughout its length, and that into this the diverticulum of the intestine, with an anal opening at its distal end, was alternately thrust and withdrawn. The fecal mass did not seem to be *carried into* this lumen by one of the eversions of the intestine, as we might now call the portion of the digestive tube that extended into the bud, but to pass directly into the cavity, *b*, and from there to the outside world by the anus at *c*.

Although the fold, *a*, changed its form and position frequently, as already explained, the movements were never seen to affect the portion of the wall of the digestive tube immediately at the entrance of the bud. From this fact and the obvious close relation of the two layers in this region, I conclude that there was an actual connection between them here. At this time both the preoral and anal bands of cilia were present, and the larva was swimming about actively. On the following morning, however, it was dead and so far decomposed as to be of no value as a preserved specimen.

Meaningless, and indeed impossible, as such a comparison would be in detail, one can hardly fail to be reminded by these figures of the young Phoronis at such a stage of its metamorphosis as is figured, for example, by Metschnikoff and copied in Lang's *Lehrbuch der Vergleichanden Anatomie.* Of course, should such a comparison be attempted, the main, or primary body of the Polygordius larva would have to be compared to the new, or secondary body of the Phoronis. Nevertheless, it is worth noticing that we have in this monstrosity, as in Phoronis, a contrivance by which the anus is transferred from the end of the body remote from the head to a position much nearer to it, this being brought about by a dorsal flexure upon itself of the digestive tract, the change being then essentially that required by Wilson's[1] speculation concerning the significance of the eversion of the digestive tract during the metamorphosis of Phoronis.—Wm. E. Ritter, University of California, Sept. 27, 1892.

[1]E. B. Wilson. The Origin and Significance of the Metamorphosis of Actinotrocha. Quart. Jour. of Micro. Sci., Vol. xxi, pp. 202–218.

PHYSIOLOGY.

The Functions of the Nervous System of the Myriapoda.—The following experiments on the nervous system of the Myriapoda were begun with the intention of continuing them upon some of the other Invertebrates, for the purpose of comparing the different relations. It has been impossible thus far to fulfil this plan, and therefore these results are given rather as preliminary than as complete in themselves.

The animal used in the experiments was the common species (*Lithobius*), and it proved a rather unfavorable subject. But the large *Iulidæ*, which would doubtless have been better, could not be obtained. The Lithobius is very active and quick in its motions, so that it was necessary to perform some of the operations while the animal was under the influence of chloroform. After the operation in most cases, some time, varying from an hour or two, to a day, according to the nature of the experiment, was allowed to pass before observations were made, this allowing recovery from the shock and from the irritation of the wound.

The method of experiment was as follows: a portion of the nervous system was removed or isolated from the rest, or destroyed by a cut or by burning with a loop of very fine platinum wire heated red-hot in an electric circuit. After recovery from the immediate effects of the operation the actions of the animal were observed at intervals until its death. The same operations were again and again repeated, so that the results given represent the observations of a large number of individual cases.

The supercœsophageal ganglion consists essentially of a small whitish mass just beneath the dorsal surface of the anterior segment, sending out two lobes transversely, which end in the nerves leading to the eyes, and just beneath these two other lobes extending forward, and giving off the nerves which pass into the antennæ. This ganglion is connected with the ventral cord by two rather thick commissures, which form a very small œsophageal ring. The ventral cord is practically the same in structure throughout its whole length, being a double cord connecting a series of ganglia corresponding to the segments of the body.

The operations upon the supercœsophageal ganglion were performed either by removing the head or some part of the ganglion by a cut, or

destroying it by means of the hot platinum wire. These operations give the following results. First, as is well known, the headless trunk shows no volition nor intelligence. If left without external stimulation it will remain quiet, until it dies, just as will the brainless frog. Yet, under stimulation, movements are made which are well coordinated, though not as perfectly so as when the ganglion is present. The trunk will start forward when touched, and will often advance its own length or more before becoming quiet again. But the motion becomes slower and slower until it ceases or until an obstacle is met, and the body is quiet until again stimulated. Some other protective motions may also be shown. The trunk will back away from a sudden stimulation in front, or the portion of the body touched may be suddenly jerked away, as in the normal animal. Further, if turned upon its back it quickly rights itself. All these actions, however, are weaker than when the superœsophageal ganglion is present, and are not performed with so much precision. The coordination of the motion of the legs is less exact, consequently the advance of the trunk is much slower, and sometimes when it is overturned several attempts are made before it succeeds in righting itself.

Another fact which is noticeable in regard to the superœsophageal ganglion, when a part of the ganglion is destroyed by the hot wire, is that the amount of influence exerted by the ganglion appears to depend on the amount of it which is left intact. A slight burn destroying only a small portion will leave the animal only a very little less active than the normal, while if the larger portion of the ganglion be burned out it is hard to distinguish the subject as regards its actions from the headless trunk. Between these two extremes there are all degrees of difference, so that it appears impossible to set any definite limit between the reflexes of the headless subject and the animal with the greater part of the superœsophageal ganglion destroyed. Moreover, the probable occasional presence of internal stimulation from the wound complicates the matter still further. Where a portion of the ganglion remains the motions continue a somewhat longer time than in the decapitated subject, and often before perfect quiet ensues, isolated motions of different legs occur at longer and longer intervals. In fact, in the two cases there seems to be an analogy to a delicate machine. In the first case, the decapitated trunk, the machine is set in motion by the stimulation but after a time comes to rest. In the second case the adjustment is more perfect and a longer time ensues before motion ceases. The delicacy of adjustment increases with the

amount of the ganglion present, until motion may be caused by stimuli so slight or of such a nature that they are not apparent.

The objection to which all experiments of this nature are more or less open may be raised here: viz, that the mutilation which is unavoidable in the operation would cause weakness and perhaps an apparent loss of function, even if no absolutely essential portions of the nervous system were removed. However, where the superœsophageal ganglion is not involved, the animal endures mutilation to such an extent without losing its volition and activity that the influence of the ganglion must be real and not apparent. Moreover, there is another fact which proves that the ganglion exercises a real influence. This fact is the presence of the so-called "forced motions" after an asymmetrical operation upon the ganglion. In all such cases the animal turns toward the uninjured side as it crawls, and thus goes about in a circle. This circular forced motion can be induced by a burn upon one side of the ganglion, and also by removal of one-half of the head with a pair of fine, sharp scissors. The animal recovers from the latter operation, and sometimes lives for twenty-four hours. The degree in which the forced motion is evident varies considerably. In some cases the diameter of the circle in which the animal moves is not more than an inch, while in other cases it is six or eight inches. The tendency to move in a circle appears to increase in strength as the animal becomes weaker, until sometimes, when nearly dead, it lies upon one side and turns within its own length. Two cases were observed in which the animal turned toward the injured side. In both these the operation was a burn on one side of the superœsophageal ganglion. Owing to accident the observations in both cases were not continued beyond the first so that the later phenomena are not known, but it seems probable that these forced motions resulted from irritation in the wound. A number of attempts were made in large specimens to cut one of the œsophageal commissures, but, owing to the extremely small œsophageal opening, and the small size of the animal, they were not successful. Steiner in a short article published a year or two since (Die Funktionen des Centralnervensystems der wirbellosen Thiere), states that with his large *Iulidae* he was able to cut a single commissure, and obtained very evident circular forced motion toward the uninjured side.

The superœsophageal ganglion, then, is a motor center to which all the motor centers lying in the ventral cord are subordinated. It enables them to respond to sensory stimuli with greater exactness and strength than would otherwise be possible. Besides this it is evidently

the center of the sense of sight and the sense of touch in the antennæ, and, moreover is the seat of whatever intelligence the animal possesses. The direction of the forced motion toward the uninjured side indicates that the fibers from the ganglion cross to the opposite side in their course. This crossing must take place in the extreme anterior portion of the ventral cord.

A part of the functions of the ventral cord are shown in the decapitated trunk. As stated above the power of coordination of motions remains to a large extent, and the animal is able to right itself when overturned. The decapitated trunk is, moreover, very sensitive to various external stimuli. A light breath of air will often set it in motion, and if the hot wire be held within one eighth of an inch the heat is usually sufficient to cause quite violent movements. This extreme sensitiveness to heat is very marked in all cases.

If now the different portions of the cord be examined, it appears that it is practically the same in function along its whole length. If a decapitated trunk be cut in half, both portions show about the same degree of activity, and neither varies much from the whole trunk except that in these smaller portions death ensues more quickly. Either of the two halves when overturned makes very evident attempts to right itself, but usually does not succeed because it is too short. If each of these halves be again cut in half, each of these pieces can still be made to advance by means of stimulation. When placed on the back some slight movements are seen which soon cease, and the piece remains perfectly quiet until again stimulated. Further than this the sense of equilibrium cannot be traced. It requires the presence of several segments in order to manifest itself. Whether, if the weakening effects of the shock and the extreme mutilation could be avoided, it would assert itself with the presence of a single ganglion cannot be definitely stated. It is, however, more probable that the coordination of more than one is necessary. The power of advancing when stimulated is still evident in a piece which possesses only three pairs of legs; a piece with two pairs of legs when stimulated makes movements, but apparently has not sufficient strength to advance. Portions of the trunk from the anterior and posterior part of the body appear about alike in these respects. Various other methods were employed in the examination of the cord, such as cutting or burning through the cord without severing the body, or destroying the supercesophageal ganglion without removing the head. They all lead to the same conclusions in regard to its functions.

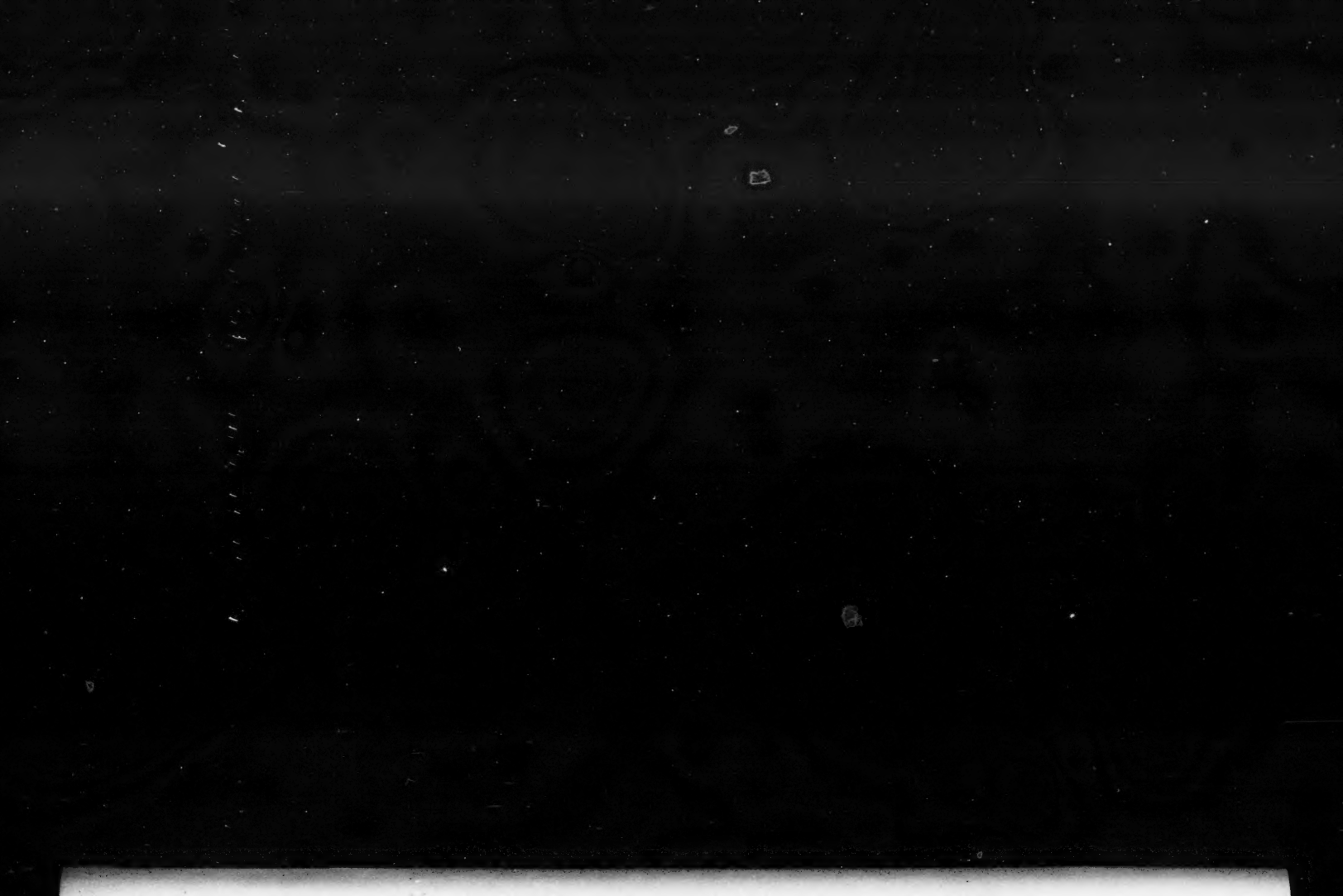
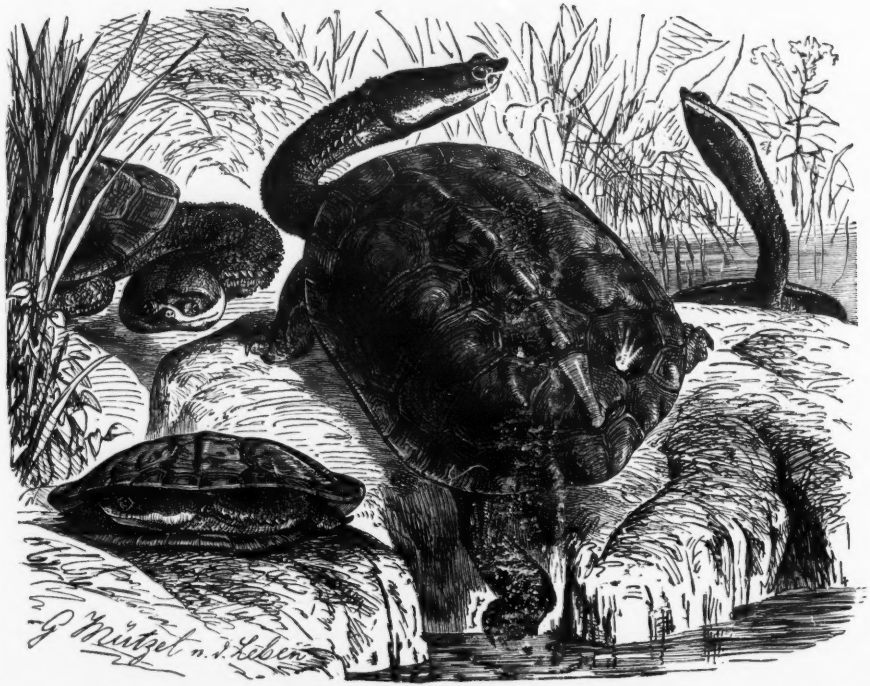
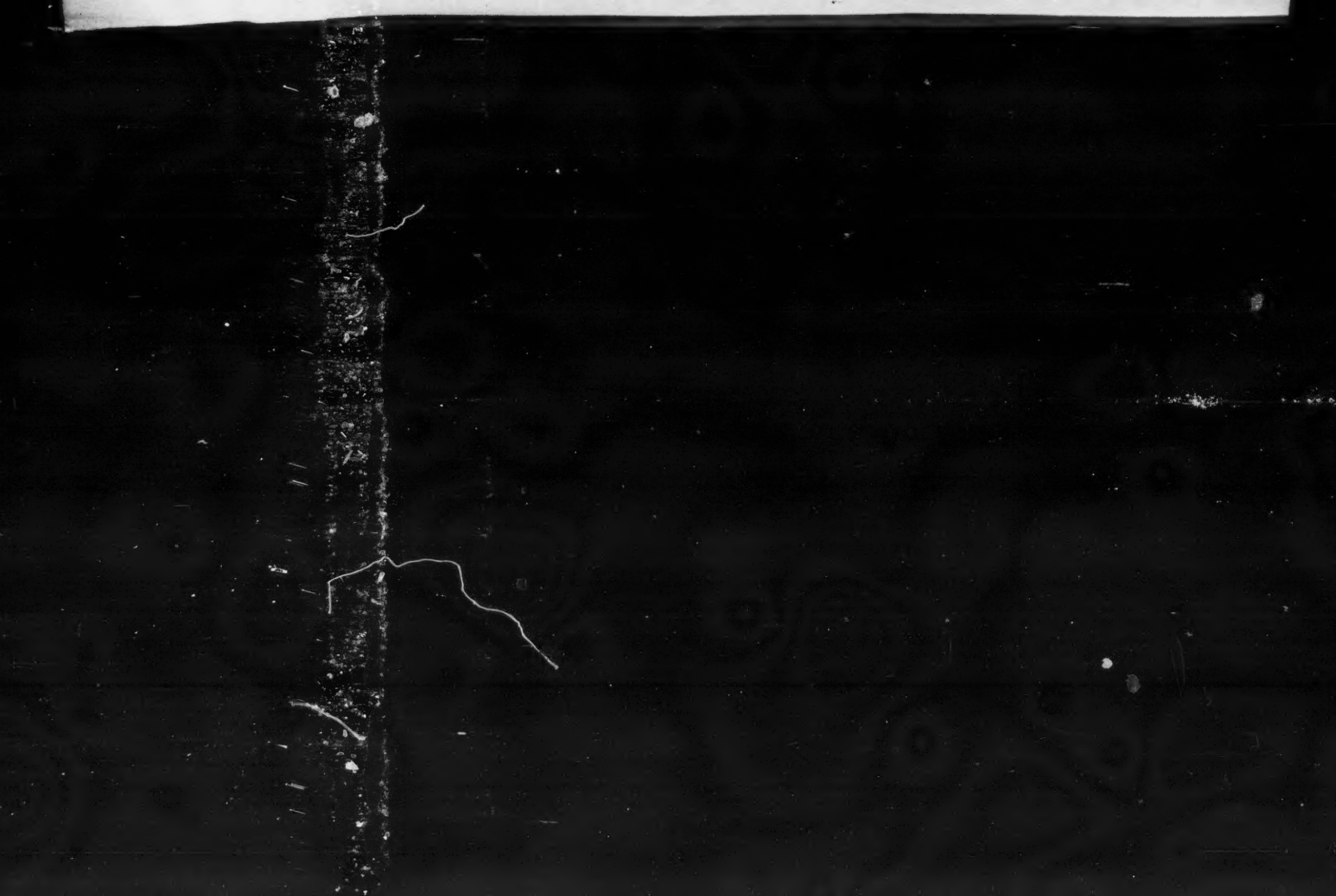


PLATE XXXI.



Hydromedusa tectifera. The snaked-necked turtle.



The nervous system of the earwig, then, consists of, first, a series of centers which are capable, unaided, of responding to sensory stimulation by appropriate coordinated motions, in other words, a series of complex reflex centers lying in the ventral cord; and second, of a single ganglion situated in the head to which all the reflex centers are subordinated, and which contains also the centers for the eye and the antennæ, and the seat of whatever intelligence may be present. Steiner (Die Funktionen des Centralnervensystems und ihre Phylogenese; Zweite Abtheilung: Die Fische) regards a true brain as defined by the presence of a general motor center together with the centers of at least one of the higher senses. The supercesophageal ganglion according to this definition is a brain, and indeed Steiner so regards it. The ventral cord is analogous in function to the spinal cord of some of the lower vertebrates, being a series of coordinated reflex centers, with perhaps some automatic functions also, all of which are subordinated to the brain.

Some experiments of a similar nature were performed upon the Decapoda, but were not continued far enough to give any definite results except that, as would be expected, the supercesophageal ganglion is a brain, and that of the ventral portion of the nervous system the thoracic ganglion is the highest and most complex in function.

A few experiments upon the horse shoe crab (*Limulus polyphemus*) revealed the fact that the presence of the chain of small ganglia running backward, or even of part of it, even when entirely separated from the rest of the nervous system was sufficient to cause regular normal motion of the gills, which continued in some cases for two days, if the animals were left undisturbed in water. The motion usually ceases when the gills are exposed to the air or when they are suddenly stimulated but in a few moments the motion begins again if they are again covered with water.

The results here given are not all new, but it is hoped that the statement concerning the more simple functions of the nervous system of the Lithobius may serve as a basis for further work, and for comparison with the results obtained from other Invertebrates.

C. M. Child.

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Middletown, Ct.

PROCEEDINGS OF SCIENTIFIC SOCIETIES.

National Academy of Sciences.—This body met at the Johns Hopkins University, Baltimore, Nov. 1, 2, and 3. The following papers were read: *The Evolution of the Moon, G. K. Gilbert; *On the Observations for Latitude at Rockville, Md., T. C. Mendenhall; *On the Latitude Observations at Honolulu, T. C. Mendenhall; *Crystallized Vegetable Proteids, Thomas B. Osborne, introduced by S. W. Johnson; *A Spectroscopic Analysis of the Rare Earths, H. A. Rowland; †A Table of Standard Wave-lengths, H. A. Rowland; On the Motion of a Sphere in a Viscous Fluid, H. A. Rowland; † Volcanic Rocks of South Mountain in Pennsylvania and Maryland, G. H. Williams, introduced by Ira Remsen; On Some Curious Double Halides, Ira Remsen; †Study of the Action of Light on Acids in Solutions Containing a Salt of Uranium, Ira Remsen; *On Isothermals and Isometrics of Viscosity, C. Barus; Significance of the Follicle of Salpa, W. K. Brooks; †Biological Relations of the Oldest Fossils, W. K. Brooks; On the Vertebrate Fauna of the Blanco Epoch, E. D. Cope; On the Motion of the Earth's Pole, S. C. Chandler; The Use of Planes and Knife-edges in Pendulums, T. C. Mendenhall; Recent Improvements in Astronomical Telescopes, C. S. Hastings; Exhibition of Photographs Illustrating New Methods and Results in Solar Physics, George E. Hale, introduced by C. S. Hastings; Some Effects of Magnetism on Chemical Action, George A. Squier and Frank A. Woff, Jr., introduced by H. A. Rowland.‡

The President announced the deaths of members of the Academy since the last meeting as follows; Lewis A. Rutherford, of New York, died May 30, 1892, and Prof. W. P. Trowbridge died August 12, 1892. Prof. B. A. Gould, of Cambridge, was appointed to write a biographical memoir of Mr. Rutherford, and Gen. C. B. Comstock, U. S. A., to prepare the memoir of Prof. Trowbridge. The deaths of two foreign associates, C. H. C. Burmeister and A. W. Hofmann, were also announced.

The following are abstracts of three of the papers read:

In Mr. G. K. Gilbert's paper on The Evolution of the Moon, he said in part: "The surface of the moon, like that of the earth, is diversified by plains, uplands and mountains, and these various features have special characters in which they differ from those of the

*Read on November 1.

†Read on November 2.

‡The remaining papers were read on November 3.

earth. The plains lie lower than other portions of the surface, and are distinguished by their darker color. By those who have mapped the surface of the moon they are called seas, but the word is used in a figurative sense, for it is well understood that there is no water on the moon. The mountains are usually in the form of rings, each ring inclosing a hollow, and to this form the name crater is given. They are scattered over the surface of the plains, and on the uplands they are thickly set, overlapping one another in every variety of relation. They are of all sizes, from the smallest that the telescope can discern to a diameter of several hundred miles. Those of medium and larger size are usually characterized by a smooth circular plain in the interior and a hill or group of hills rising in the center of the plain. They differ from the craters of the earth in various ways, especially in the fact that their bottoms are below the level of the surrounding country, and in the fact that the central hill bears no crater on its summit.

"The origin of these craters has been the subject of many theories. Despite their marked peculiarities of form, they have more commonly been ascribed to volcanic action; but they have also been referred to the bursting of gigantic bubbles, to the evaporation of water and its accumulation about the point of evaporation as ice, and to the impact of bodies from without. Personally, I favor the last mentioned explanation, but I differ from other writers in respect to the origin of the colliding bodies. It has been previously surmised that these might be rocks hurled from terrestrial volcanoes; that they might be meteors from the recesses of space, such as are continually burned in the upper layers of our atmosphere, giving rise to shooting stars, and that they might be aggregates of such meteors constituting balls of cosmic dust. Now my idea of their origin is based upon the phenomena of the planet Saturn and its ring. About that planet is a disc-like ring which astronomers believe to be constituted of an indefinitely large number of very small bodies revolving about the planet in parallel orbits—a symmetrically shaped form of small satellites. Assume that a similar ring of minute satellites once encircled the earth, and that these gradually became aggregated into a smaller number of larger satellites, and eventually into a single satellite—the moon. The craters mark the spots where the last of the small bodies collided with the surface when they finally lost their independence and joined the larger body.

In Prof. G. H. Williams' paper on The Volcanic Rocks of South Mountain in Pennsylvania and Maryland, he announced that during the past summer he had been able to clearly identify over 175 square

miles of rocks exposed along the eastern side of South Mountain as ancient lavas. "These rocks," he continued, "have been heretofore often described by geologists, but have been considered to be of sedimentary origin. To any one, however, familiar with the products of recent volcanic regions the proofs of their lava character are convincing. In spite of their great age and complete recrystallization they still retain the minutest details of their original structures. Even under the microscope they are hardly to be distinguished from recent glassy or half-glassy rocks from the Yellowstone Park or from southern Italy. In chemical composition also they show surprisingly little change.

These old volcanic rocks present two sharply contrasted types. One is basic in composition and agrees in all respects with our recent basalts, the other is acid in composition and belongs to the group of lavas called porphyry, or rhyolite. In South Mountain the rocks of the latter class, which occupy about twice as much space as the basic ones, have been called slates, while their green, basic contemporaries have been known as chlorite schists. The discovery of such extensive lava fields in such wonderful preservation and so near at hand was unexpected, and deserves attention on account of its local interest.

The age of the lavas and their relations to the sandstone of the mountain, which Mr. Walcott has recently shown to be of the oldest known fossil-bearing horizon, was then explained. Attention was called to the fact that, as in most volcanic regions, large deposits of fragmental material occur (breccias, ashes, etc.), which have heretofore been considered as sedimentary beds. A large map of South Mountain, on a scale of three miles to the inch, was exhibited to show the distribution of all these rocks. Numerous specimens of the rocks themselves were also shown. Many of the porphyries are of great beauty, and are capable of extensive application in the arts, especially when polished for purposes of interior decoration."

Prof. E. D. Cope's paper was on The Fauna of the Blanco Epoch. Prof. Cope said in part: "The formation known as the Blanco has been discovered by Texan geologists and forms a part of the Great Staked Plain. I visited this region," he said, "the geology of which has been so much misunderstood, last spring, and obtained numerous fossil remains, from which I have determined fifteen species of vertebrata, all new to science and constituting a fauna intermediate between two previously known faunæ, and filling an important gap in the history of life on this continent. The species found included two tortoises, one bird, one sloth, three mastodons, one peccary, three horses, one

camel, and three carnivora. The most interesting discovery is that of a hyena, a form which has not hitherto been found in America. Its size is about that of the living spotted hyena. The other carnivora are a weasel the size of a fisher, and a cat about the size of a cheetah, both new to science. Two of the mastodons are very large, and the first (*Dibelodon humboldtii*) has hitherto been found only in South America, and the second (*D. tropicus*) in Mexico, while the third is new to science (*D. præcursor*). The horses are true species of the genus Equus—having but one toe—but one of them is remarkable for its small size, as its teeth do not exceed in size those of a sheep. The peccary is entirely a new form, while the camel ranks somewhere between the ordinary camel and the Procamelus, somewhat exceeding the ordinary camel in size."

The Biological Society of Washington.—Nov. 5, 1892—The following communications were read: The Fauna and Flora of Roan Mountain, N. C., Dr. C. Hart Merriam; Pea and Bean Weevils, Prof. C. V. Riley; The Influence of the Cross Timbers on the Fauna of Texas, Mr. Vernon Bailey. FREDERICK A. LUCAS, Secretary.

Boston Society of Natural History.—Nov. 2.—The following paper was read: Certain Aspects of the Vegetation of New Zealand, Prof. George L. Goodale.—SAMUEL HENSHAW, Secretary.

The New York Academy of Sciences has recently organized a Biological Section, which will hold monthly meetings. At the opening meeting, Oct. 17, Prof. Henry F. Osborn acted as chairman. The following papers were presented: Bashford Dean on Dionæa Under Its Native Conditions Near Wilmington, N. C.; the results of experiments emphasizing the plant's erratic sensibility and its special adaptation for capturing ground insects. N. L. Britton on a species of Hieracium; E. B. Wilson on The Artificial Production of Twins and Multiple Embryos in Amphioxus. The paper dealt mainly with the peculiarities of double monsters produced (as in Driesch's experiments on Echinus) by shaking apart the blastomeres of two- and four-celled stages, (vide Anatomischer Anzeiger, 1892.) Every gradation exists between the two perfect and separate bodies, each half the normal size, and four in which the only indication of duality consists of a bilobed condition of the archenteron. In the double gastrulas the long axes of the two halves may form any angle with each other, and the two blastopores when separate may be turned in any direction. In cases where the two blastopores face each other the two bodies are

united by a bridge of tissue at one side essentially as in the double gastrulas of certain earthworms.

SCIENTIFIC NEWS

The Indiana Academy of Science is engaged in the publication of its proceedings since its establishment several years ago. The publication is in the hands of a committee consisting of Prof. O. P. Hay, of Butler University; Prof. C. A. Waldo, of Depauw University, and Pres. John M. Coulter, of the Indiana University. No State organization holding its meetings but once a year has better meetings with a greater variety of interesting papers than this association.

The American Microscopical Society has issued a special circular which may be obtained by all interested, of Dr. William H. Seaman, Secretary, Washington, D. C. The circular gives an outline of the proceedings of the last meeting of the Society, held at Rochester Aug. 9–12, 1892, from which we gather the following items: Twenty-nine new members were elected and twenty-seven papers were presented. The following officers were elected for the ensuing year: President, Prof. J. D. Cox, of Cincinnati; Vice-Presidents, Dr. Geo. M. Sternberg, of Brooklyn; Dr. A. C. Mercer, of Syracuse; Secretary, Dr. Wm. H. Seaman, of Washington; Treasurer, Mr. Charles C. Mellor, of Pittsburg. The circular also gives the following announcement regarding prizes offered by the Society:

The following sums of money have been placed at the disposal of the society, to be given as prizes for the encouragement of microscopical research, and Profs. Gage, Kellicott, and Seaman were appointed a committee to prepare the conditions on which they should be granted. The competition will be open to members of the society and to those who make application for membership before submitting their papers to the committee:

Two prizes of $50, two prizes of $30, two prizes of $25, two prizes of $15. The committee have prescribed the following conditions:

One prize of $50 for the best paper which shall give the results of an original investigation relating to *animal* life, made with the microscope, and not less than 3000 words in length. The methods by which the results are obtained to be given in full.

One prize of $50 for the best paper which shall give the results of an original investigation made with the microscope and relating to *plant* life, not less than 3000 words in length. The methods by which the results are obtained to be given in full.

Two prizes of $25 each for the second best papers on animal and plant life respectively, on the above conditions.

The papers, drawings and specimens entered for the above prizes to be submitted to the committee on or before July 1, 1893, and the papers and drawings to be published in the Proceedings.

One prize of $30 for the best six photomicrographs on some subject in animal or vegetable histology whose structural features are to be illustrated by the photomicrographs of the following amplification, viz., 50, 150 and 500, two of each. These are to be made by transmitted light, printed on albumen paper from untouched negatives, which with the specimens from which they are made, are to be submitted with the pictures to the committee.

One prize of $30 for the best selection of six mounted slides illustrating some one biological subject. These slides must be accompanied by a full description of the method of preparation of the specimens.

Two prizes of $15 each for the second best collection of photomicrographs and slides respectively, on the conditions above stated.

All photographs and mounted slides for which prizes are given are to become the property of the society. The object of these prizes is to stimulate and encourage original investigation in the Biology of North America, and if additional information is desired it may be obtained of the committee on prizes.

Dr. Harris H. Wilder has been appointed Professor of Biology in Smith College, Northampton, Mass.

Dr. Henry B. Ward has been appointed Instructor in Zoology in the University of Michigan.

Dr. C. S. Minot has been elected Professor of Histology and Embryology in Harvard Medical College.

November 5, 1892, was given up by the Mechanics Fair in Boston to the Marine Biological Laboratory at Woods Holl. There were illustrations of the work of the laboratory, sets of the specimens furnished schools and colleges by the department of supplies of the laboratory, and addresses outlining the history, purposes and results of the station by trustees, pupils, etc.

The handsome new natural history hall at the University of Illinois, at Champaign, was dedicated Nov. 16. The trustees, faculty and students of the University and a large number of citizens and visitors from a distance were present. This handsome new structure has been in course of erection since October, 1891. The most approved methods of lighting and ventilation have been used in the construction of the building. It will be heated by steam as the other University buildings are. It is three stories high. The lower story is of blue limestone from Bedford, Ind., and the remaining two stories and dormer windows are of red compressed brick, and roof of slate. The windows and cornices are neatly trimmed with stone and terra cotta. The cost is about $78,000. This building will be devoted exclusively to the study of the natural sciences. It will contain the natural history library, containing more than 20,000 volumes, natural history museum, laboratories and recitation rooms. At a meeting of the trustees of the University of Illinois to-day it was decided to petition the Legislature for $350,000 to put into new buildings—a chapel, a museum and engineering building. The crowded condition of the University makes these additions necessary.